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Information Technology Management Based From Technology Component Contribution Assessment On Academic Information System: A Case Study

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Abstract. This study evaluates the academic information system at ITENAS using the Technology Contribution Coefficient (TCC) approach. The TCC values based on perceptions of lecturers, staff, and students were 0.718, 0.713, and 0.690, respectively. While staff and lecturers viewed the system as modern and effective, students perceived it as only moderately effective. This perception gap is primarily attributed to deficiencies in the Inforware component, especially in documentation quality and accessibility. Moreover, the low contribution intensities of Inforware (0.116) and Orgaware (0.081) reflect their underappreciated strategic role by the institution's technical task unit. To address these issues, improvement strategies must begin with a comprehensive usability evaluation, focusing on learnability, efficiency, memorability, effectiveness, and satisfaction. Emphasis is placed on the development of better supporting documentation, such as SOPs and work instructions (WIs), using participatory design methods. Tools like storyboards—developed through Hierarchical Task Analysis—can enhance users' understanding and engagement. These approaches strengthen the Humanware aspect by aligning user needs with system functionality.Improving Orgaware maturity through usability testing and refining system documentation is expected to indirectly enhance Humanware performance. This study recommends future research to assist the technical task unit in conducting usability assessments and redesigning the system through a human-centered, participatory design approach to ensure sustainable and user-driven improvements.

Keywords: *technometric, technoware, humanware, inforware, orgaware, information system*

1 Introduction

The adoption of Industry 4.0 technologies—such as cyber-physical systems and real-time data exchange—demands a clear digital strategy, implementation roadmap, and assessment

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of organizational readiness [1]. While these technologies promise cost efficiency and productivity gains, many organizations deploy them without evaluating alignment with existing processes .
The COVID-19 pandemic accelerated this need in education, making information systems essential for organizational sustainability. At ITENAS, the Academic Information System (SIKAD), managed by computer and IT units, supports lecturers, students, and staff in core activities like advising, attendance tracking, and grading.
Evaluating SIKAD's contribution requires addressing two sustainability dimensions: (1) leveraging technology for more sustainable academic processes, and (2) ensuring the technology's own long-term viability[2]. Ultimately, SIKAD must enhance efficiency and data accuracy while minimizing environmental impact, promoting responsible digital practices, and reducing resource waste.
Information technology significantly transforms organizations and their modes of operation [3]. Effective IT systems enhance decision-making and performance [4], but they must adapt to dynamic organizational needs .
Technology plays a dual role in organizational transformation—it offers opportunities for innovation and growth while also introducing complexity and uncertainty [5]. Recognizing this duality is vital when designing academic information systems that must align with both technical specifications and organizational objectives.
As organizations evolve, people must continuously learn and adapt to technological changes. The development and implementation of an information system involve various elements—humans, hardware, software, communication networks, and databases—that work together to gather, process, and disseminate information [3]. The dynamic nature of these components often leads to new challenges, requiring ongoing adjustments during system development.

An information system is, at its core, a structured integration of people and technology, encompassing hardware, software, networks, and databases [4]. Its functionality hinges on four key components: (1) facilities and human resources, (2) documented procedures, (3) organizational structures and workflows, and (4) interactions among them . Mastering these dynamics is essential for managing complexity and ensuring successful implementation.
Digital organizational culture—shared values shaping operations in digital environments—builds trust in technology and drives transformation. Yet, resistance to change remains a major barrier, often requiring leadership to shift from top-down control to participatory, flexible styles [7].
The implementation of information technology depends on students, lecturers, and staff. The IT unit must prioritize user acceptance to maximize benefits and performance. SIKAD usage intensified during the pandemic among diverse users, underscoring the need for this research to assess harmony between the system's technological components and its human users.

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2 Method

2.1 Respondents

This research involves lecturers, students and staff using the academic information system at Itenas. The sampling method used is probability sampling because all population members have equal opportunity to become a sample. Population is nonhomogeneous, so to determine sample numbers, we use a disproportionate stratified random sampling method.
Data from the Human Resource Bureau shows that active lecturers from undergraduate and master's degree amounts to 233 personnel from all faculties. Meanwhile, data from technical task unit of computer and information technology showed 6801 undergraduate students during semester 1 of 2022/2023.
From these data, with a 5% margin of error, we obtained 142 samples from lecturers and 332 students. Staff involved in using the academic information system are 18 people; therefore, we use census for our sampling. For this research, we gathered 203 lecturers, 339 students, and 18 staff as respondents, with all faculties and departments represented

2.2 Technometric Methods

This research applies the technometric method to evaluate technological content in ITENAS's Academic Information System (SIKAD) by measuring four components: Technoware, Humanware, Infoware, and Orgaware. These interconnected elements act as input transformers, converting inputs to outputs , with sophistication levels varying across components. [6]. The Technology Atlas Project views technology as physical tools plus related knowledge, classifying it into four basics [6]:

- Technology that manifests itself as an object, called facility or technoware
- Technology manifested in humans, called skills or humanware
- Technology manifested as documents, called facts or inforware,
- Technology manifested as institution/ organization, called frameworks or aware

By assessing these, the technometric model gauges their collective 'technological contribution' to transformation sophistication, enabling a comprehensive evaluation of system performance.
In this model, we use the Technology Contribution Coefficient (TCC), which refers to the intensity of contribution for each component towards TCC. This is defined for transformation facility with the following formula [6]:

$$TCC = T^{\beta_T} \times TH^{\beta_H} \times I^{\beta_I} \times O^{\beta_o} \quad (1)$$

With T, H, I, and O describing individual contributions from Technoware, Humanware, Inforware and Orgaware. The multiplicative nature of TCC implies:

- The function of TCC shows that contribution factors are non-zero, implying transformation cannot occur without any of the four components.

– Results are reduced when there are efforts to improve technology level by improving only one component while keeping others constant. Applying partial derivative to TCC (eq.1) over T showed that:

$$\frac{\partial(TCC)}{\partial T} = \beta_t \frac{TCC}{T} \quad (2)$$

This shows that the phenomenon described above will be satisfied if, in the case of technoware, $0 < \beta_t < 1$. A similar conclusion can be made for other components by applying similar partial derivative operations.

$$\frac{d(TCC)}{TCC} = \beta_t \frac{d(T)}{T} + \beta_h \frac{d(H)}{H} + \beta_i \frac{d(I)}{I} + \beta_o \frac{d(O)}{O} \quad (3)$$

therefore

$$\frac{d(TCC)}{TCC} = \beta_t \frac{d(T)}{T} + \beta_h \frac{d(H)}{H} + \beta_i \frac{d(I)}{I} + \beta_o \frac{d(O)}{O} \quad (4)$$

This shows that the proportional increase of TCC equals the sum of the proportional increase of all four components, weighted by β_i. If all four components are added with similar ratio, eq. 4 reduces to

$$\frac{d(TCC)}{TCC} = p\left[\beta_t + \beta_h + \beta_i + \beta_o\right] \quad (5)$$

Therefore, if $\beta_t + \beta_h + \beta_i + \beta_o < 1$, then the TCC function satisfies result scale conditions, be it increasing, neutral, or decreasing.
Technology Contribution Coefficient (TCC) assessment is done through several steps:

2.2.1 Estimation of Degree of Sophistication

Qualitatively analyze the four technology components (Technoware, Humanware, Infoware, Orgaware) in the academic information system using Table 1 [6]. Collect data via interviews with IT unit staff to assign sophistication scores, establishing upper limit (UL) and lower limit (LL) values for each.

Table 1 Degree of Sophistication and Assessment Procedure for 4 Technology Components

Technoware	Humanware	Inforware	Orgaware	Score		
Manual facility	Operating capability	Recognizing operation	Striving framework	1	2	3
Powered facility	Setup capability	Imaging operation	Combination framework	2	3	4

General function facility	Repair capability	Choice operation	Exploration framework	3	4	5
Special function facility	Reproducing capability	Usage information	Protection Framework	4	5	6
Automated facility	Adapting capability	Comprehension information	Stability Framework	5	6	7
Computerized facility	Improvement capability	Improvement information	Opportunity searching framework	6	7	8
Integrated facility	Innovating capability	Assessment information	Leadership framework	7	8	9

2.2.2 *State-of-the-Art assessment*

Determining the status of a component for certain kinds of transformation facilities in comparison with state-of-the-art (SoTA) will require extensive knowledge about technical performance specs. SoTA assessment for each component is done through questionnaires designed based on SoTA evaluation criteria. Academic information system assessment criteria used for each component are shown in Table 2. Based on the aforementioned criteria, four questionnaires are made in relation to each academic information system component with 0-10-scale scoring

Table 2 Assessment of Criteria for State-of-the-Art Academic Information System

Technoware	Humanware	Inforaware	Orgaware
Scope (of operations)	Creativity (potential)	Retrievability (ease of)	Stakeholder (orientation)
Precision (required)	Risk Bearing (capacity)	Communicability (ease of)	Innovation (climate for)
Handling (required)	Affiliation (orientation)	Updating (possibility of)	Direction (sense of)
Merit (of Technoware)	Efficiency (orientation)		

Before a questionnaire is distributed, it must undergo rigorous validity and reliability testing to ensure the instrument accurately measures the intended constructs and yields consistent results. Validity testing is essential to confirm that each item reflects the conceptual domain it is meant to assess and is suitable within the research context. This process typically involves face validity, content validity, and construct validity assessments[8], which emphasized that face, content, and construct validity are necessary to establish the logical coherence of measurement tools [9].
Reliability testing, on the other hand, ensures the internal consistency and stability of the instrument over time. It involves statistical analysis such as Cronbach's alpha and test–retest procedures to examine whether repeated applications of the questionnaire produce consistent outcomes. Both studies reported high reliability coefficients, confirming that the instruments were free from significant random errors and capable of delivering stable, replicable [8], [9].

Results from the validity test showed that all questions were valid when the value recalculated> table, with a stable value of 0.361. The reliability test is obtained based on the value calculated using the Cronbach's α formula, where higher scores correlate with higher reliability for the scale used. Internal consistency varies from zero to 1, which was assessed using Cronbach's alpha. Scales with internal consistency coefficients > 0.7 were regarded as acceptable results [9]. In this study, the reliability test result obtained a Cronbach's α value of 0.924. Therefore, this questionnaire can be considered reliable with Cronbach's α ≥ 0.70. With the questionnaire validated and proven reliable, the questionnaire can now be distributed to all respondents. State-of-the-art research for academic information systems is done towards the distribution of the questionnaire based on SoTA rating equations [6]:
technoware for item i:

$$ST_i = \frac{1}{10}\left[\frac{\sum_{1}^{k_t} t_{ik}}{k_t}\right] \quad k = 1, 2, \ldots, k_t \tag{6}$$

humanware for item j:

$$SH_l = \frac{1}{10}\left[\frac{\sum_{1}^{l_h} h_{ij}}{l_h}\right] \quad l = 1, 2, \ldots, l_h \tag{7}$$

inforware:

$$SI = \frac{1}{10}\left[\frac{\sum_{1}^{m_f} f_m}{m_t}\right] \quad m = 1, 2, \ldots, m_f \tag{8}$$

orgaware:

$$SO = \frac{1}{10}\left[\frac{\sum_{1}^{n_o} O_n}{n_o}\right] \quad n = 1, 2, \ldots, n_o \tag{9}$$

With:

t_{ik} = i-th criterion score for Technoware k
k_t = Numbers of Technoware component criteria
h_{ij} = i-th criterion score for Humanware j
l_h = Numbers of Humanware component criteria
f_m = m-th criterion score for Inforware at the company level
m_t = Numbers of Inforware component criteria
O_n = n-th criterion score for Orgaware at the company level
n_o = Numbers of Orgaware component criteria

2.2.3 Determining contributing component

Based on the limit of degrees of sophistication and SoTA, the contribution from each component can be calculated [6]:

$$T_i = \frac{1}{9}\left[LT_i + ST_i\left(UT_i - LT_i\right)\right] \tag{10}$$

$$H_l = \frac{1}{9}\left[LH_l + SH_l\left(UH_l - LH_l\right)\right] \tag{11}$$

$$I = \frac{1}{9}[LI + SI(UI - LI)] \tag{12}$$

$$O = \frac{1}{9}[LO + SO(UO - LO)] \tag{13}$$

Value Ti shows the contribution of each item i of Technoware, with Hj showing the contribution from j category of humanware. Division by nine ensures maximum contribution value to SoTA is 1

2.2.4 Assessment of the contribution intensity (β)

The intensity of each component's contribution is estimated using a paired comparison matrix approach. All four components are hierarchically arranged in accordance with their importance. Suitable β with respective components will later be arranged in similar relative importance levels. Relative importance value β at a certain level is compared with value β on the next level, measured with a scaled paired comparison procedure [6], shown in Table 3.

Table 3 Scales of Paired Comparison Level of Importance

Absolute-scale level of importance	Definition
1	Equal importance
3	Slightly more important
5	Quite important
7	Very important
9	Absolute importance
2,4,6,8	Intermediate value

Estimating relative importance from paired comparison matrix is designed to maintain consistency, with tests carried out by obtaining eigenvectors from a normalized matrix.

2.2.5 Technology Contribution Coefficient (TCC) calculation

Using values T, H, I, O and ß, Technology Contribution Coefficient (TCC) can be calculated by eq. 1. Because T, H, I, and O are all less than one and the sum of ß equals 1 (after normalized), maximum TCC value is 1 [6]. This calculation result will later be compared with classification, determining which categories this TCC value belongs to. Said classification can be seen in Table 4 [10]

Tabel 4 TCC classification & levels of technology according to TCC

TCC	Classification	Levels of technology
0,0 < TCC ≤ 0,1	Very low	Traditional
0,1 < TCC ≤ 0,3	Low	Traditional
0,3 <TCC ≤ 0,5	Reasonable	Semi Modern
0,5 <TCC ≤ 0,7	Good	Semi Modern
0,7 <TCC ≤ 0,9	Very good	Modern
0,9 <TCC ≤ 1,0	Sophistication	Modern

3 RESULTS AND DISCUSSION

3.1.1 Academic Information System Degree of Sophistication

Based on Table 1, UL and LL values for degrees of sophistication for every academic information system component can be seen in Table 5. UL and LL value represents the expected value from the technical task unit of computer and information technology regarding academic information system use.

Tabel 5. Upper level and lower level of Degree of Sophistication in Academic Information System

Components	academic information system degree of sophistication	
	Lower Limit	Upper Limit
Technoware (System)	LT: 5	UT: 8
Humanware (lecturer, student, staff)	LH: 5	UH: 7
Inforware	LI: 1	UI: 7
Orgaware (technical task unit of computer and information technology)	LO: 1	UO: 9

3.1.2 State-of-The-Art (SoTA) of Academic Information System's component

Data obtained from questionnaires filled out by lecturers, students and staff formed a basis for SoTA assessment for each component of the academic information system. Table 6 shows data processing results using Eq. 6, 7, 8, and 9.

Tabel 6. State-of-The-Art (SoTA) of Academic Information System's Component

Component	Lecturer	Staff	Student
Technoware	0,685	0,717	0,616
Humanware	0,738	0,747	0,623
Inforware	0,591	0,603	0,561
Orgaware	0,690	0,548	0,605

The SoTA values reflect the perceptions of each respondent group regarding the readiness and capability of the system components. Across all three groups—lecturers, staff, and students—Humanware consistently received the highest SoTA score, suggesting that users are generally confident and competent in utilizing the academic information system. This indicates a strong alignment between user capabilities and the technological functions of the system.

In contrast, Inforware received the lowest SoTA scores across all groups. This highlights a significant weakness in the system's supporting documentation and information resources, which are essential for guiding users, enabling transformation, and preventing implementation setbacks. The inadequacy in this component could potentially hinder the broader success of the system's integration within the institution.

Furthermore, the data reveal a noticeable perception gap between lecturers/staff and students. While faculty and administrative personnel rated most components more favorably, students demonstrated lower SoTA values, particularly in Inforware and Orgaware. This suggests that user acceptance is not uniform across groups. The acceptance of academic systems is strongly influenced by perceived usefulness, data quality, and organizational support, which directly shape how users engage with and evaluate the system[11].

In the case of ITENAS, students' comparatively lower evaluations likely stem from limited exposure to the system's full functionalities, inadequate communication during system disruptions, and insufficient access to support resources. Therefore, improving the Inforware and Orgaware components should focus on strengthening these acceptance drivers, such as increasing information clarity, enhancing support channels, and ensuring transparent communication,to reduce gaps in user experience and perception across different stakeholder groups.

An analysis of each component reveals that the lowest contributing criteria to the State-of-the-Art (SoTA) of the academic information system are consistent across all user groups. As summarized in Table 7, the Technoware and Inforware components record the lowest SoTA values for lecturers, staff, and students alike.

Tabel 7. State-of-the-art Criteria of Academic Information System

<table>
<tr><th>Component</th><th>Lecturer</th><th>Staff</th><th>Student</th></tr>
<tr><td>Technoware</td><td colspan="3">Network condition</td></tr>
<tr><td>Humanware</td><td>Comprehension of academic information system features</td><td>Communication with technical task unit of computer and information technology</td><td>Staffs' initiative</td></tr>
<tr><td>Inforware</td><td colspan="3">Informations regarding interruption/downtime</td></tr>
<tr><td>Orgaware</td><td>Building conducive environment</td><td colspan="2">Technical task unit of computer and information technology responsiveness</td></tr>
</table>

Technoware: Unstable network infrastructure universally hinders system access and performance across all users, especially during peak times.

Infoware: Low SoTA stems from poor communication about downtime; users report frustration due to the IT unit's lack of timely, clear updates.

Humanware (highest overall SoTA: 0.738):

- Lecturers score lowest on feature comprehension (7.103/10) but excel in problem-solving initiative and IT support engagement.
- Staff need better IT unit coordination.
- Students lack initiative, likely from limited awareness or empowerment.

Orgaware:
- Lecturers cite insufficient conducive environments, pointing to institutional challenges.
- Staff and students highlight unresponsive IT support, calling for more agile mechanisms.

These gaps in infrastructure (Technoware), communication (Infoware), and support (Orgaware) underscore the need for targeted upgrades to boost user satisfaction and system transformation.

Overall, these findings emphasize the necessity for improvements in infrastructure reliability (Technoware), proactive communication during disruptions (Inforware), and responsive organizational support (Orgaware). Addressing these core issues would enhance user satisfaction and support the transformation of academic information systems.

3.1.3 Contributions of the Technology Component of the Academic Information System

The contribution of each component was calculated using Equations 10 to 13, based on the data in Tables 5 and 6. The results indicate the relative contribution of each component, where a value of 1 reflects a high contribution and high degree of sophistication, while a value of 0 reflects a low contribution and an obsolete component.
Table 8 presents the calculated contributions of the four main components—Technoware, Humanware, Inforware, and Orgaware—from the perspectives of lecturers, staff, and students. The findings show that Inforware has the lowest degree of contribution across all three groups, indicating a critical area in need of improvement. Meanwhile, Technoware shows the highest contribution, suggesting that the physical and technical infrastructure of the academic information system is relatively well-developed.

Table 8 Component Contribution to Academic Information System

Component	Lecturer	Staff	Student
Technoware	0,784	0,794	0,761
Humanware	0,719	0,722	0,694
Inforware	0,505	0,513	0,485
Orgaware	0,721	0,598	0,649

These values emphasize that while the technical and human aspects of the system are relatively strong, the informational and organizational components require further attention—particularly from the perspective of students and staff. Strengthening Inforware and Orgaware is essential for ensuring balanced development and effective implementation of the academic information system.

3.1.4 Determining contribution intensity of each component

The contribution intensity of each component, denoted as β, was determined using the Analytical Hierarchy Process (AHP). This process involves pairwise comparisons of the components, followed by the calculation of eigenvectors that represent the relative importance or priority of each component in the academic information system.
The eigenvectors derived from the AHP process reflect the weighted contribution intensity of the four components, Technoware, Humanware, Inforware, and Orgaware. These values are presented in Table 9. The results indicate that Technoware and Humanware are considered significantly more critical compared to Inforware and Orgaware.

Table 9 Contribution Intensity of Academic Information System's Component

Component	T	H	I	O	Total	Intensity, β
Technoware	0,427	0,395	0,525	0,417	1,763	0.441
Humanware	0,427	0,395	0,375	0,250	1,447	0,362
Inforware	0,061	0,079	0,075	0,250	0,465	0,116
Orgaware	0,085	0,132	0,025	0,083	0,325	0,081
Total	1,00	1,00	1,00	1,00	4,00	1,00

The AHP results affirm that Technoware (β= 0.441) and Humanware (β = 0.362) are perceived as the primary contributors to the effectiveness and sophistication of the academic information system. In contrast, Inforware (β = 0.116) and Orgaware (β = 0.081) exhibit lower contribution intensities, indicating that these components are undervalued or underutilized in the current system structure.
These findings highlight the need to re-evaluate and strengthen the role of Inforware and Orgaware to ensure a more balanced and integrated system development approach.

3.1.5 Technology Contribution Coefficient of Academic Information System

The Technology Contribution Coefficient (TCC) is calculated to assess the contribution level and classify the technological sophistication of the academic information system. This coefficient is determined using Equation 1, with values derived from the perceptions of lecturers, staff, and students. The results are summarized in Table 10.

Tabel 10 Technology Contribution Coefficient Academic Information System

Component	Contribution to each component			Intensity, β
	Lecturer	Staffs	Students	
Technoware	0,784	0,794	0,761	0.441
Humanware	0,719	0,722	0,694	0,362
Inforware	0,505	0,513	0,485	0,116
Orgaware	0,721	0,598	0,649	0,081

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Technology Contribution Coefficient (TCC)	**0.718**	**0.713**	**0,690**
Classification	$0,7 < TCC \leq 0,9$ **Very good**		$0,5 < TCC \leq 0,$ **Good**
Levels of sophistication	**Modern**		**Semi modern**

The TCC reflects both the technological readiness and sophistication of the system. While the contribution intensity (β) values are relatively consistent across groups, the TCC values vary, particularly between students and the other two respondent groups. These differences reflect perceptual gaps in the evaluation of individual technology components.

A substantial gap is observed between Technoware and the other three components, highlighting an imbalance in the system. The most notable divergence appears in Inforware, where students rated its contribution significantly lower than lecturers and staff.

Although the overall contribution intensity (β) remains consistent, differences in TCC classifications across respondent groups reveal disparities in perception. Lecturers and staff classified the system as modern and very good, whereas students rated it only semi-modern and good.

This discrepancy arises from the comparatively lower humanware and inforware contributions perceived by students. In contrast, staff rated the orgaware component lower than both students and lecturers. These perceptual differences suggest that the academic information system is not experienced uniformly across user groups, and highlight the need for targeted improvements, especially in the inforware and orgaware components, to ensure more equitable user satisfaction and engagement

3.1.6 Technology Component Analysis

The value of the Technology Contribution Coefficient (TCC) is directly influenced by the contribution levels of the four main technology components: Technoware, Humanware, Inforware, and Orgaware. These contributions, based on the perceptions of lecturers, students, and staff, are illustrated in Figure 1.

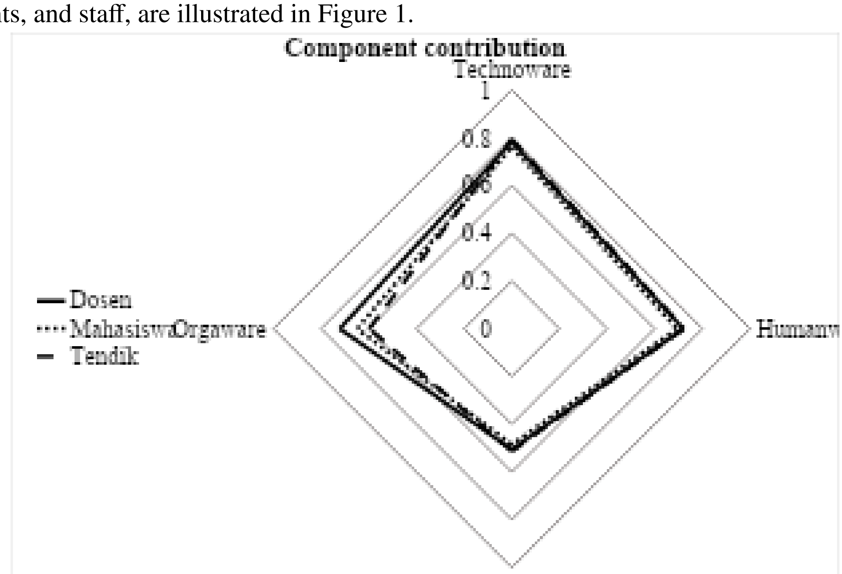

Figure 1. his diagram is based on the perceptions of lecturers, students and staff

In the radar chart above, a value of 1 represents a highly sophisticated component, while 0 indicates obsolescence. Overall, none of the components achieved full sophistication, and Inforware consistently shows the lowest contribution across all respondent groups—indicating it is the least sophisticated and potentially obsolete.

Technoware

From all perspectives, Technoware has the highest contribution, consistently scoring above 0.7, suggesting that the hardware and software infrastructure of the academic information system is approaching a modern, sophisticated level. Although it has not yet reached full maturity, its level of sophistication is relatively strong, especially in terms of access, reliability, and system features.

Humanware

The Humanware component—reflecting user capability and interaction—shows a slight variation across respondent groups. Students reported lower contribution scores (just below 0.7) compared to lecturers and staff. This disparity may stem from differences in system engagement. Students typically interact with the academic system only during key academic moments such as registration, schedule checks, and viewing grades. In contrast, lecturers and staff use the system more intensively and consistently, leading to stronger perceived contributions in this area. Skills in system navigation, initiative in problem-solving, and collaboration with IT support also contribute to this gap.

Inforware

Inforware represents the weakest link in the system's technological makeup. Despite the availability of user manuals and guides on the institutional IT unit's webpage, students and lecturers report limited access to real-time, contextual, or troubleshooting information. Critical issues include the lack of timely updates during downtime, maintenance periods, or system errors. This information gap can create frustration and diminish the overall user experience, ultimately reducing system trust and effectiveness

Orgaware

The Orgaware component—relating to organizational readiness, governance, and support—received low scores, particularly from students and staff. Respondents highlighted a perceived lack of responsiveness from the IT unit, weak feedback mechanisms, and low trust in the system's administration and development processes. The lack of visible and timely support erodes confidence in the academic system’s organizational backbone.

Although Inforware and Orgaware scored low in both contribution and intensity (β), the high score of Technoware helps maintain the overall TCC in the “good to very good” classification. This indicates that while hardware and user capabilities are relatively adequate, information management and organizational support are areas that require immediate improvement.

To ensure sustainable improvement, these components must not be seen in isolation. All four elements interact simultaneously and must evolve in harmony to support technological transformation. Therefore, Itenas must prioritize systematic assessments of institutional resource capabilities—including the needs and readiness of lecturers, staff, and students.

Moreover, Information and Communication Technology (and institutional goals. A user-centered design approach is critical to foster engagement, usability, and long-term adoption of the academic information system.

3.1.7 Strategy for the improvement of contributions from all technology components of the Academic Information System

One of the institution’s missions is to develop a science-tech-based management system that fosters a conducive academic environment. The technical unit responsible for IT has not yet fully achieved this, with services and system implementation remaining suboptimal for the academic community.

Technometric results reveal fragmented management: Inforware (0.116) and Orgaware (0.081) contribute least, undervaluing critical enablers. Systematic technology management is essential, as cultural resistance and low digital readiness often derail transformation [12], [13]. Addressing these gaps—via enhanced documentation, structures, and culture—will align IT with institutional goals and boost system effectiveness. A strong digital culture is essential to adapt to VUCA (volatile, uncertain, complex, and ambiguous) conditions, as misalignment between people, leadership, and tech goals can hinder success [7].

Improving the system requires both robust infrastructure and pedagogical-tech training for lecturers and students [14]. At Itenas, lecturers need digital pedagogical skills from pre-service training, supported by ongoing technical training. These initiatives enhance system use and digital readiness among students.

Student technology acceptance depends on motivation, mindset, collaboration, and perceived ease and usefulness[15][16][17] . Cognitive demands from digital systems can increase stress [18], so system design must consider both usability and organizational support[11].

Low contributions of Inforware and Orgaware at Itenas stem not only from technical gaps but also from weak organizational responsiveness and lack of participatory design, which reduces student engagement. These elements must be restructured: Inforware through better documentation and information flow, Orgaware through improved governance and responsiveness, in alignment with Humanware capabilities—especially student perceptions.

In Industry 4.0, ergonomics has expanded to cognitive aspects, focusing on human-tech interaction to maintain performance and well-being [19]. Innovation also strengthens employee commitment, acting as a mediator under technological stress [5]. Thus, system

improvements must consider not only technical aspects but also organizational factors such as work activities, communication, and user engagement [19].
Orgaware should implement a robust evaluation system. The current usability assessment uses Nielsen's model, focusing on error prevention, efficiency, and satisfaction [18], [20][21] Usability encompasses learnability, efficiency, memorability, error tolerance, and user satisfaction. Student perception significantly affects motivation and digital learning success[17]. [22][23], and this is affected by mindset, which in turn affects behaviour [17].
Stakeholder involvement is critical. Participatory Action Research (PAR) offers a framework to involve students, faculty, and IT staff in collaborative system development [24]. PAR enhances ownership, contextual relevance, and long-term system sustainability. At Itenas, PAR can align Inforware and Orgaware redesign with user needs.
Finally, Nielsen-based usability testing reveals gaps: 42% of respondents disagreed that the system prevents errors or provides a satisfying experience. Students criticized the interface and data timeliness. Thus, improvements should start with Orgaware, particularly its evaluation function, alongside broader efforts to address software incompatibility and system redesign [4].

3.1.8 Implications of the Implementation of Improvement Strategy for Academic Information System's Component

The improvement strategies proposed in the previous sections have both technical and organizational implications for the academic information system at ITENAS. These strategies are not limited to enhancing infrastructure or user training, but also involve restructuring the way technology components—particularly Inforware and Orgaware—are conceptualized, managed, and aligned with Humanware capabilities. Implementation of these strategies requires a system-wide shift that integrates participatory approaches, cognitive ergonomics, and macroergonomic principles.
In relation to Inforware, as a component representing information and documentation, the implications of improvement efforts lie in the need for more structured, accessible, and user-oriented documentation. This includes:

- Enhancing the availability and completeness of Standard Operating Procedures (SOPs) and Work Instructions (WIs), as well as other essential supporting documents that guide system users.
- Designing SOPs and WIs that are not only technically complete but also intuitively helpful. These documents should serve as instructional tools that assist students, lecturers, and staff in understanding how to effectively use the academic information system.

One promising approach is to develop storyboards—visual, step-by-step narratives illustrating how users interact with the system to achieve specific tasks[25]. Each storyboard represents a single line of activity, making it possible to develop different storyboards tailored to specific user tasks or scenarios. This helps address varied user needs and contextual challenges faced during system interaction.
These storyboards should be based on Hierarchy Task Analysis (HTA), a method that examines user interaction with the system by identifying what tasks are performed, how

critical they are, and the way users carry them out. This method is rooted in cognitive engineering, allowing developers to collect scenario-based data to inform storyboard creation. In the early stages of system redesign, the use of Participatory Design (PD) is recommended. As a common approach in human factors and ergonomics, PD incorporates student and staff perspectives into the creation of WI and SOP documentation, thereby increasing system relevance and acceptance [26]

Collectively, these methods reflect a human-centered design philosophy—placing users at the core of the design process. This ensures that usability testing and documentation design prioritize Humanware, enhancing user experience, reducing cognitive load, and promoting better adoption of the academic information system.

Furthermore, applying these strategies has broader implications for the performance of the technical task unit of computer and information technology. By restructuring how Inforware and Orgaware are developed and maintained, the institution can improve system responsiveness, student engagement, and alignment with institutional goals. Ultimately, this contributes to a more sustainable and effective academic information system—one that supports long-term digital transformation and continuous user development in line with the principles of Industry 4.0.

4 CONCLUSION

The Technology Contribution Coefficient (TCC) for the academic information system, as perceived by lecturers, staff, and students, was 0.718, 0.713, and 0.690, respectively. While staff and lecturers considered the system to be modern and effective, students rated it lower—indicating a perception gap primarily driven by weaknesses in the Inforware component. Additionally, the technical task unit has not fully acknowledged the strategic importance of Inforware and Orgaware, with low contribution intensities of 0.116 and 0.081.

To address this, improvements must begin with a comprehensive evaluation of the academic information system, focusing on usability aspects such as learnability, efficiency, memorability, effectiveness, and user satisfaction. The application of participatory design, especially in the development of SOPs and WIs, is essential to improve user engagement, particularly among students. This approach strengthens the Humanware dimension while enhancing Inforware and Orgaware.

Improvement strategies should start by increasing Orgaware maturity through usability testing, followed by refinement of the system’s usability features. Supporting documentation must also be made more accessible and easier to understand. Enhancing these components will indirectly improve the Humanware value and overall system performance.

Future research is recommended to support the technical task unit in conducting usability evaluations and in redesigning the academic information system, including its supporting documents, through a human-centered and participatory approach

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