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Article

Exploring biometric attendance technology in the Arab academic environment: Insights into faculty loyalty and educational performance in policy initiatives

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Abstract: This study provides insights for decision-makers contemplating the implementation of Biometric Attendance Technology (BAT) for faculty in educational institutions. We conducted a comprehensive assessment of BAT's impact on Arab educational systems, focusing on its influence on faculty loyalty and satisfaction, which are integral to enhancing overall organizational performance. Using SMART-PLS, we analyzed data from an electronic questionnaire distributed to 296 participants. Our findings highlight the importance of fostering faculty loyalty and satisfaction through training and education initiatives alongside BAT implementation strategies. Despite these efforts, there was no significant improvement in the relationship between loyalty, satisfaction, and educational system performance (ESP) following the introduction of BAT. Slope analysis indicated no significant correlations between Faculty Member Satisfaction (FMS), Faculty Member Loyalty (FML), and ESP. However, slight improvements in R-square values were observed: FML increased from 0.512 to 0.514, and ESP from 0.433 to 0.438 with the BAT moderator. These results are crucial for guiding informed decisions regarding the integration of modern technologies into educational systems.

Keywords: Biometric Attendance Technology (BAT); educational systems; cultural factors; human-oriented perspective; Arab region

1. Introduction

The social impact of Biometric Attendance Technology (BAT) implementations has been linked to economic growth, as researched by Necochea-Chamorro et al. (2024), Mir et al. (2018), and Suale et al. (2023). However, the broader field of studies has been criticized for neglecting certain subpopulations and the cross-cultural, cross-border research in the policy literature (Lacko et al., 2022). Given the significance and impact of automation on individuals and organizations, a lack of attention to how it interacts with social contexts, particularly cultural factors at the user level, may lead to negative externalities (Eriksson et al., 2023).

This study is significant because it raises awareness of the cultural significance of user-driven automation in Arab industrial culture, which is incomprehensible in terms of its effects on both managers and workers in educational systems. Designing "one-size-fits-all" policies for differing social norms can lead to democratization and control issues, as highlighted in the 2006 ACM/IEEE-CS IT research directive (Chatila and Havens, 2019). Therefore, interdisciplinary and international computer science efforts are required to benefit both knowledge generators and society more broadly. Other authors have provided instances that show how societies in the Arab and Gulf regions differ greatly from those in the West (El Sayed et al., 2023) and (Langworthy and Naguib, 2024):

1) Cultural Priorities: Compared to the more individualistic principles common in Western nations, traditional values, and societal standards are frequently valued more highly in the Arab and Gulf areas.
2) Workplace Dynamics: Compared to Western corporate cultures, Arab and Gulf workplaces tend to have more prominent hierarchical structures and respect for authority, which has a distinct impact on organizational behavior and decision-making.
3) Technology Adoption: Cultural views on privacy, trust, and the place of technology in daily life might influence attitudes toward technology, including biometric attendance tracking systems.
4) Educational Policies: Due to wider cultural norms and societal values, educational institutions in the Arab and Gulf countries may place a higher priority on attendance than on student production.
5) Social Norms: Social conduct and workplace dynamics may be impacted by the major differences between Arab and Gulf countries and Western cultures in terms of societal values, gender roles, and family dynamics.

The cultural, social, and institutional distinctions between Western nations and the Arab and Gulf areas are exemplified by these instances.

The study contributes to the relationship between BAT and its effects on faculty members, work organization, and education system performance in the Arab and Gulf regions. It proposes a hybrid approach addressing both the implementation of BAT and a human-oriented perspective (Satisfaction and Loyalty). The implication is to provide a framework for process-mechanization customization that addresses both learning enterprise and human-directed technology policies, as discussed by Shannaq et al. (2010, 2024a, 2024b). The study uses a multi-group structural model to provide educational leaders with useful insights on BAT task-operation adjustments.

The two main contributions of the study are:

- Humanizing technology in educational workplaces through a proposed integration of different automation and employee-oriented approaches in a hybrid attendance control system.
- It provides empirical evidence from the Middle East, specifically the Arab regions, on the acceptance and use of emerging technologies such as BAT in the educational environment.

This study focuses on a problem specific to the Arab and Gulf regions, which differ significantly from Western societal values. In the focus regions, older officials prioritize attendance and absence policies over employee productivity, which can negatively impact system performance (Al-Shamsi and Shannaq, 2023; Rashid Al-Shamsi and Shannaq, 2024). Employees often disagree with modern technologies, believing they undermine loyalty and integrity (Arai, 2023, 2024; Awwad, 2024; Shakir et al., 2024; Shannaq, 2024c). This research is unique in its focus on the Arab community and the relationship between attendance technology and organizational performance. The study aims to develop effective monitoring and control procedures before investing in expensive technology systems, enhancing productivity and reducing potential risks.

Overall, this study fills a significant gap in the literature review and offers theoretical and practical insights that could improve the use of technology in educational settings and other contexts. Educational leaders may gain valuable insights from this study on how to integrate BAT systems effectively, combining technological efficiency with human components. Our framework creates the groundwork for future study and policy development in many cultural settings and provides insights for the culturally sensitive application of biometric technologies in education, thereby bridging the gap between technology and user experience.

2. Materials and methods

To support the results shown in the study, a structural equations method was implemented (Hair et al., 2019). The reasons for choosing which structural equations to apply are as follows:

a. The underlying premise of path analysis sometimes referred to as causal modeling, implies that variables are causally related to one another. It is possible to test hypotheses and change the parameters of a causal model that is represented by linear equations.
b. Causal models may contain manifest variables, latent variables, or both;
c. Confirmatory factor analysis is an approach that builds upon traditional factor analysis and is used to investigate specific assumptions about the makeup of factor loadings and their interrelationships.

The proposed conceptual with the research issue and its significance. Next, we review the current literature to determine the applicability of ideas and previous studies to our inquiry, thereby establishing a solid theoretical foundation. We then identify and define the key ideas and elements that our study will address with accuracy. Afterward, we articulate the connections between these ideas and elements, formulating hypotheses based on existing research and theoretical frameworks. Finally, we visually represent this framework by creating a model or diagram that illustrates how these important concepts and variables interrelate, using arrows for connections and boxes for concepts

In **Figure 1**, the suggested conceptual framework is shown.

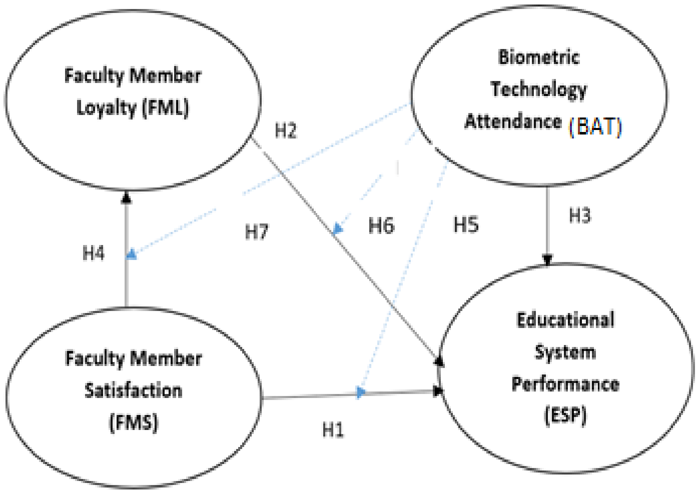


Figure 1. Conceptual framework.

Based on the proposed conceptual model (**Figure 1**), the following research questions, objectives, and hypotheses have been developed:

Research Questions:

- What is the impact of using Biometric Technology Attendance (BAT) on the relationship between Faculty Member Loyalty (FML) and Education System Performance (ESP)?
- What is the impact of using Biometric Technology Attendance (BAT) on the relationship between Faculty Member Satisfaction (FMS) and Education System Performance (ESP)?
- What is the impact of using Biometric Technology Attendance (BAT) on the relationship between Faculty Member Loyalty (FML) and Faculty Member Satisfaction (FMS)?

Objectives

- To assess how Biometric Technology Attendance (BAT) affects Education System Performance (ESP).
- To assess how Biometric Technology Attendance (BAT) affects the relationship between Faculty Member Loyalty (FML) and Faculty Member Satisfaction (FMS).

Hypotheses:

- H1: The efficacy of the Education System Performance (ESP) is significantly enhanced by increasing Faculty Member Satisfaction (FMS).
- H2: The efficacy of the Education System Performance (ESP) is significantly enhanced by increasing Faculty Member Loyalty (FML).
- H3: The efficacy of the Education System Performance (ESP) is significantly enhanced by applying Biometric Technology Attendance (BAT).
- H4: Faculty Member Satisfaction (FMS), mediated by Faculty Member Loyalty (FML), has a favorable impact on Education System Performance (ESP).
- H5: Biometric Technology Attendance (BAT) positively moderates the relationship between Faculty Member Satisfaction (FMS) and Education System Performance (ESP).

- H6: Biometric Technology Attendance (BAT) positively moderates the relationship between Faculty Member Loyalty (FML), and Education System Performance (ESP).
- H7: Biometric Technology Attendance (BAT) positively moderates the relationship between Faculty Member Satisfaction (FMS) and Faculty Member Loyalty (FML).

These theories and metrics offer a thorough framework for researching Biometric Technology Attendance (BAT) affects the connections between academic Achievement, faculty member's loyalty, and satisfaction.

2.1. The process for collecting and selecting samples of data

The collected information has 296 occurrences and 20 attributes. For the sample frame, a non-probability strategy was implemented and shared by email due to time constraints. Convenience sampling supplied educators with relevant information. After reviewing relevant research and defining our goals, we created an e-questionnaire in Google Forms with three independent variables FML, FMS, BAT, and one dependent variable ESP. The questions were evaluated to ensure clarity. The e-questionnaire was then distributed via Google Drive to faculty members.

We sent the survey to 411 faculty members working in universities in the Sultanate of Oman. The random selection was based on the availability of their email addresses and existing collaborations between the researchers. Out of the 411, only 296 faculty members responded and completed the survey.

The dataset used in our study consists of 296 occurrences, each representing individual faculty members, and includes 20 attributes. These attributes encompass various demographic, professional, and biometric data points pertinent to the faculty members and their interactions with the Biometric Technology Attendance (BAT) system. **Table 1** outlines the survey structure. **Figure 2** illustrates the distribution of faculty member specializations (major), **Figure 3** shows the distribution of faculty members by the country where they obtained their higher degrees, **Figure 4** depicts the distribution of faculty members by age, and **Figure 5** presents the distribution of faculty members by academic experience. The Link to the survey is available in (Survey Link, 2024).

This sample size was deemed adequate for analysis based on previous research (Hair et al., 2019, 2021).

Table 1. Survey structure.

Demographic Data	
1-specialization major; 2-university from which faculty member obtained his higher degree; 3-Age; 4-experience year in academic teaching.	
Survey Questions	
Variable (IV)	**Type of questions**
1. Faculty Member Satisfaction (FMS)	1) Job Satisfaction Index. 2) Work-life balance 3) Professional development 4) Recognition and rewards 5) Administrative support.

Table 1. (*Continued*).

Demographic Data	
1-specialization major; 2-university from which faculty member obtained his higher degree; 3-Age; 4-experience year in academic teaching.	
Survey Questions	
Variable (IV)	**Type of questions**
2. Faculty Member Loyalty (FML)	1) Retention rate 2) Advocacy 3) Commitment 4) Engagement 5) turnover intention
3. Biometric Technology Attendance (BAT)	1) accuracy of attendance 2) Faculty compliance 3) Administrative efficiency 4) Data security and privacy 5) Faculty perception of fairness
Variable (DV)	**Type of questions**
4. Educational System Performance (ESP)	1) Graduation rate 2) Student achievement 3) Employment rate 4) Research and innovation 5) Student satisfaction
Feedback	

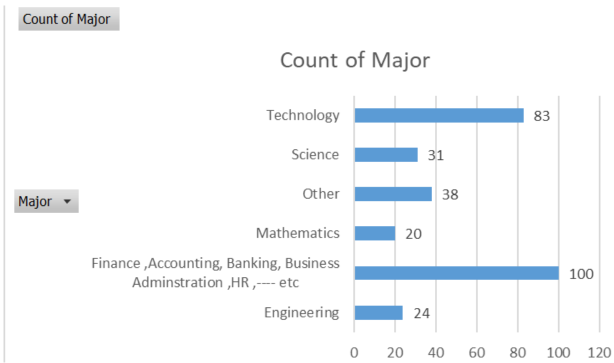


Figure 2. Distribution of faculty member specializations (major).

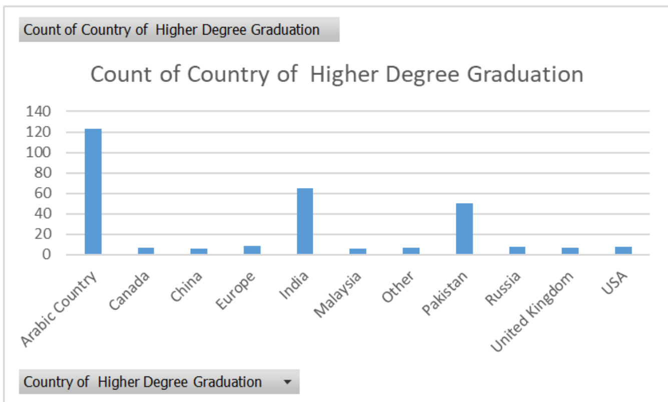


Figure 3. Distribution of faculty members by country of their higher degree graduation.

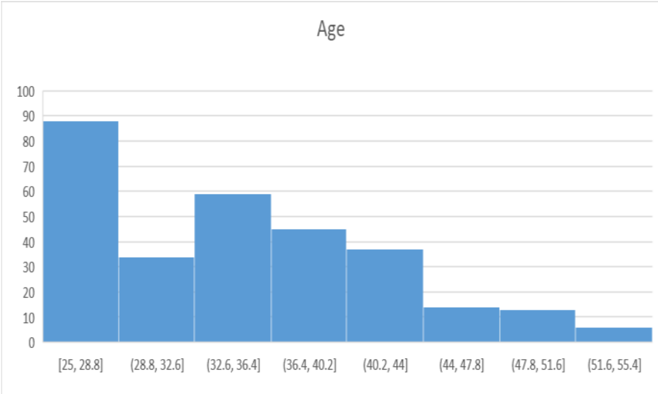
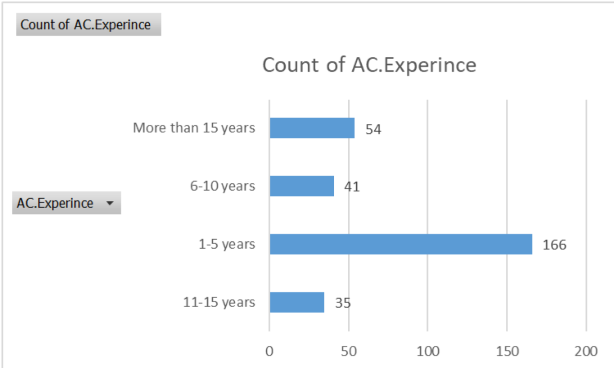


Figure 4. Distribution of faculty members by age.



Indicators 20
Samples 296
Missing values 0

Name	No.	Type	Missings	Mean	Median	Scale min	Scale max	Observed min	Observed max	Standard deviation	Excess kurtosis
1.1 FMS	1	MET	0	3.078	4.000	1.000	5.000	1.000	5.000	1.476	-1.462
1.2 FMS	2	MET	0	2.980	3.000	1.000	5.000	1.000	5.000	1.520	-1.547
1.3 FMS	3	MET	0	3.324	3.000	1.000	5.000	1.000	5.000	1.204	-0.813
1.4 FMS	4	MET	0	3.490	4.000	1.000	5.000	1.000	5.000	1.136	-0.478
1.5 FMS	5	MET	0	3.389	3.000	1.000	5.000	1.000	5.000	1.122	-0.642
2.1 FML	6	MET	0	3.030	4.000	1.000	5.000	1.000	5.000	1.496	-1.512
2.2 FML	7	MET	0	3.395	4.000	1.000	5.000	1.000	5.000	1.206	-0.812
2.3 FML	8	MET	0	2.831	3.000	1.000	5.000	1.000	5.000	1.583	-1.628
2.4 FML	9	MET	0	3.358	3.000	1.000	5.000	1.000	5.000	1.157	-0.654
2.5 FML	10	MET	0	3.351	3.000	1.000	5.000	1.000	5.000	1.105	-0.607
3.1 BAT	11	MET	0	3.399	4.000	1.000	5.000	1.000	5.000	1.382	-1.050
3.2 BAT	12	MET	0	3.514	4.000	1.000	5.000	1.000	5.000	1.227	-0.701
3.3 BAT	13	MET	0	3.689	4.000	1.000	5.000	1.000	5.000	1.141	-0.387
3.4 BAT	14	MET	0	3.659	4.000	1.000	5.000	1.000	5.000	1.122	-0.238
3.5 BAT	15	MET	0	3.733	4.000	1.000	5.000	1.000	5.000	1.084	0.007
4.1 ESP	16	MET	0	3.311	4.000	1.000	5.000	1.000	5.000	1.513	-1.311
4.2 ESP	17	MET	0	3.534	4.000	1.000	5.000	1.000	5.000	1.208	-0.474

Indicators
Correlations
Data groups
Raw data

Figure 6. Data descriptive statistics.

2.2. Practice for cleaning data

After receiving the data in CSV format from Google Forms (Survey Link, 2024), we completed the data cleaning process in SPSS. Initially, we confirmed the accuracy of the dataset's highest and lowest values on the five-point Likert scale (1 to 5). Then searched for anomalies and examined missing data from necessary form fields, but we were unable to find any. Finally, we evaluated replies that were out of the ordinary using standard deviation (SD). With SD-Min = 0.489 and SD-Max = 1.605, in **Figure 6** the descriptive statistics show that the data is suitable for analysis based on earlier studies (Hair et al., 2021). The recommended threshold for the standard deviation (STDEV) is greater than 0.25.

3. Results and discussion

3.1. Model of assessment: Measurement model

3.1.1. Validity and reliability

Validity and reliability were assessed using Cronbach's Alpha and Composite Reliability (CR). Initially, the dataset contained items with factor loadings below 0.700 (e.g., 3.2 BAT = 0.321 and 3.5 BAT = 0.427), which were subsequently eliminated. This process is illustrated in **Figure 7** (before removal) and **Figure 8** (after removal). However, indicators 3.1 BAT = 0.596 and 2.2 FML = 0.696 were retained. Their removal did not significantly impact the average variance extracted (AVE) threshold, which is above 0.50, or the variance inflation factor (VIF) threshold, which is below 5, as supported by previous studies (Hair et al., 2021). Hence, the Cronbach's Alpha and Composite Reliability (CR) have been established. AVE and HTMT were used in extensive testing that led to this finding. The remaining items' reliability and validity, together with their factor loadings, are shown in **Table 2**. All alpha values demonstrate robust reliability, as does CR over the recommended cutoff point of 0.700. Convergent validity was confirmed by the AVE and CR values, which were both equal to or greater than 0.500 and 0.700, respectively. The discriminant validity of the cross-loadings was established by factor loadings exceeding cross-loadings for every item.

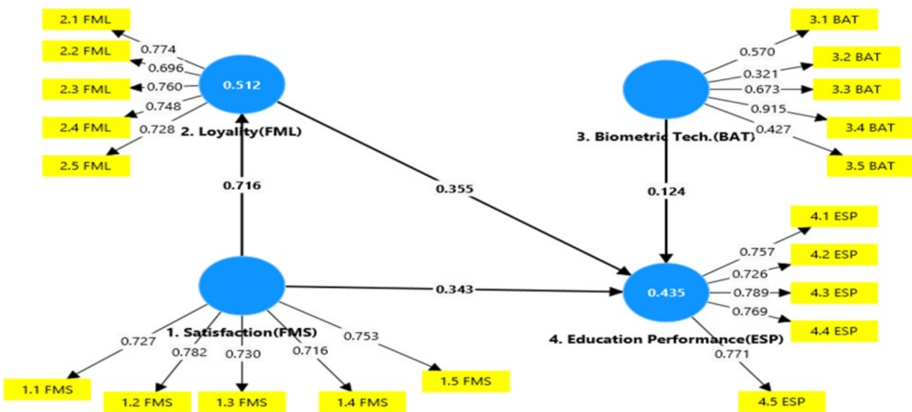


Figure 7. Factor loading (primary data).

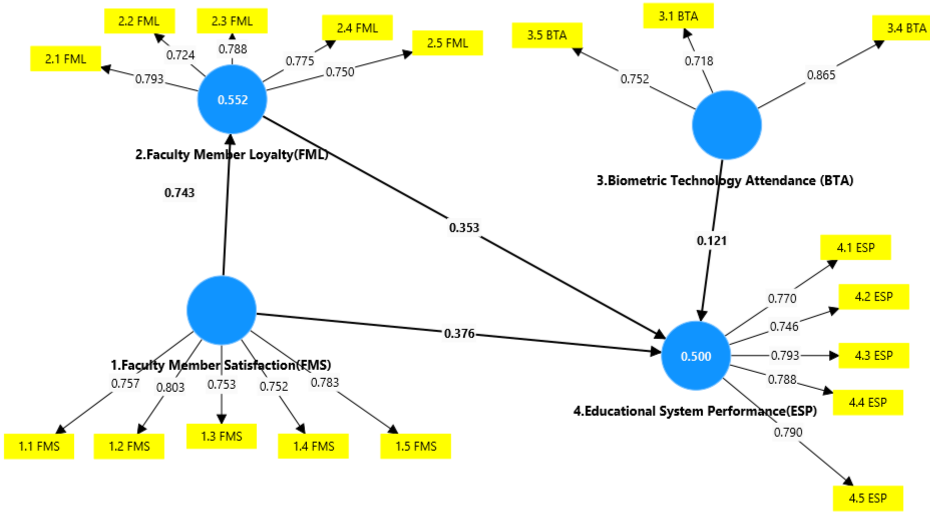


Figure 8. Factor loading (after removal: 3.2 BAT = 0.321, 3.5 BAT = 0.427).

Table 2. Item loadings, reliability, and validity.

	Factor Loading	**Cronbach's alpha**	**Composite reliability (rho_a)**	**Composite reliability (rho_c)**	**Average variance extracted (AVE)**
Faculty Member Satisfaction (FMS)		**0.796**	**0.8**	**0.859**	**0.55**
1.1 FMS ← 1. Satisfaction (FMS)	0.757				
1.2 FMS ← 1. Satisfaction (FMS)	0.803				
1.3 FMS ← 1. Satisfaction (FMS)	0.753				
1.4 FMS ← 1. Satisfaction (FMS)	0.752				
1.5 FMS ← 1. Satisfaction (FMS)	0.783				
Faculty Member Loyalty (FML)		**0.796**	**0.799**	**0.859**	**0.55**
2.1 FML ← 2. Loyalty (FML)	0.793				
2.2 FML ← 2. Loyalty (FML)	0.724				
2.3 FML ← 2. Loyalty (FML)	0.788				
2.4 FML ← 2. Loyalty (FML)	0.775				
2.5 FML ← 2. Loyalty (FML)	0.750				
Biometric Technology Attendance (BAT)		**0.658**	**0.948**	**0.792**	**0.567**
3.1 BTA ← 3.Biometric Technology Attendance (BTA)	0.718				
3.4 BTA ← 3.Biometric Technology Attendance (BTA)	0.865				
3.5 BTA ← 3.Biometric Technology Attendance (BTA)	0.752				
Educational System Performance (ESP)		**0.821**	**0.827**	**0.874**	**0.581**
4.1 ESP ← 4. Education Performance (ESP)	0.770				
4.2 ESP ← 4. Education Performance (ESP)	0.746				
4.3 ESP ← 4. Education Performance (ESP)	0.793				
4.4 ESP ← 4. Education Performance (ESP)	0.788				
4.5 ESP ← 4. Education Performance (ESP)	0.790				

3.1.2. Predictive validity

According to the criteria set forth by Discriminant validity "Heterotrait-monotrait ratio HTMT" is presented in **Table 3**, and "Fornell & Larcker," is presented in T**able 4**. Therefore, the predictive validity was further confirmed, with additional confirmation of discriminant validity.

Table 3. 'HTMT'.

	1. Satisfaction (FMS)	2. Loyalty (FML)	3. Biometric Tech. (BAT)	4. Education Performance (ESP)
1. Satisfaction (FMS)				
2. Loyalty (FML)	0.891			
3. Biometric Tech. (BAT)	0.162	0.163		
4. Education Performance (ESP)	0.773	0.765	0.266	

Table 4. "Fornell & Larcker".

	1. Satisfaction (FMS)	2. Loyalty (FML)	3. Biometric Tech. (BAT)	4. Education Performance (ESP)
1. Satisfaction (FMS)	0.77			
2. Loyalty (FML)	0.743	0.766		
3. Biometric Tech. (BAT)	0.125	0.121	0.781	
4. Education Performance (ESP)	0.654	0.647	0.211	0.778

3.2. Model of assessment: Structural model

In the following phase of our research, we undertook an evaluation of the structural models to investigate the proposed hypotheses. The Moderator BAT examines the impact of the relationships between FML and ESP, between FMS and ESP, and between FML and FMS, as depicted in **Figure 9**. **Table 5** presents the direct testing of the hypotheses.

Table 5. Testing hypotheses directly.

	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	*P* values
1. Satisfaction (FMS) → 4. Education Performance (ESP)	0.352	0.066	5.309	0.000
2. Loyalty (FML) → 4. Education Performance (ESP)	0.345	0.066	5.248	0.000
3. Biometric Tech. (BAT) → 4. Education Performance (ESP)	0.118	0.053	2.206	0.027

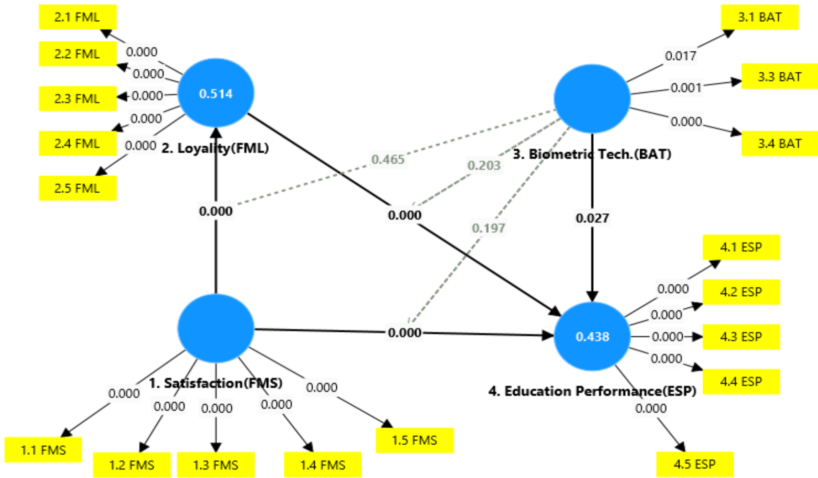


Figure 9. Bootstrapping implementation for mediator & moderator analysis.

3.2.1. Testing hypotheses directly

A decision was made to conduct a two-tailed test with a t-value of −1.96 and a significance level of 95%. This choice was informed by the data presented in **Table 5**, which indicated significant findings for the hypothesis H1, H2, and H3. The results revealed a substantial influence of FMS on ESP (B = 0.352, t = 5.309, p = 0.000), thereby supporting hypothesis H1. Furthermore, FML had a significant impact on ESP (B = 0.335, t = 5.248, p = 0.000), providing support for hypothesis H2. The results also revealed a substantial influence of BAT on ESP (B = 0.118, t = 2.206, p = 0.027), thereby supporting hypothesis H3. The testing of H4, H5, H6, and H7 will be detailed in the following sections.

3.2.2. Mediation analysis

Figure 9 demonstrates the implementation of the mediation analysis using "Bootstrapping."

Table 6. Result summary (mediator analysis H4: FMS → FML → ESP).

Total effect		Direct Effect		Specific indirect effect							
B	**P**	**B**	**P**	**Hypothesis**	**B**	**t**	**UL**	**LL**	**P**	**Results**	
0.597	0.000	0.352	0.000	H4 FMS -> FML -> ESP	0.245	5.099	0.150	0.339	0.00	Partial Mediation	**H4: Accepted**

H4 aims to assess how Faculty member loyalty (FML) mediates the connection between the effectiveness of Faculty member Satisfaction (FMS) and education system performance (ESP): ("Satisfaction (FMS) → Loyalty (FML) → Education Performance (ESP)"). Based on the data from **Table 6** and H4, there exists a notable indirect relationship between Faculty member Satisfaction (FMS) and the effectiveness of Education system Performance (ESP) (B = 0.245, t = 5.099, p = 0.000). The path analysis depicted in **Figure 5** indicates that the mediator's Faculty member loyalty (FML) influence was deemed significant (p < 0.05) when there was a direct correlation between Faculty member Satisfaction FMS and a notable indirect effect of Education system Performance (ESP). Given the significant direct and specific indirect effects, it is evident that Faculty member loyalty (FML) partially mediates the relationship between Faculty member Satisfaction (FMS) and Education system

Performance (ESP). Faculty member loyalty also controls the association between FMS and ESP, indicating that high levels of FML weaken the positive relationship between FMS and ESP.

3.2.3. Moderator analysis

The results presented in **Table 7** show that BAT does not significantly influence the relationships (H5: BAT × FMS → ESP), (H6: BAT × FML → ESP), and (H7: BAT × FMS → FML). Hence, hypotheses H5, H6, and H7 have been rejected.

Table 7. Moderator results.

	Original sample (O)	**Sample mean (M)**	**Standard deviation (STDEV)**	**T statistics (|O/STDEV|)**	***P* values**
3. Biometric Tech. (BAT) × 1. Satisfaction (FMS) → 2. Loyalty (FML)	0.038	0.035	0.052	0.731	0.233
3. Biometric Tech. (BAT) × 1. Satisfaction (FMS) → 4. Education Performance (ESP)	0.091	0.082	0.07	1.291	0.098
3. Biometric Tech. (BAT) × 2. Loyalty (FML) → 4. Education Performance (ESP)	−0.086	−0.083	0.067	1.273	0.102

The moderation analysis was conducted to assess the moderating role of Biometric Technology Attendance (BAT) on the relationships between FMS and FML, FMS and ESP, and FML and ESP. The study proposed that the implementation of BAT would positively moderate the relationship between FMS and ESP (H5), between FML and ESP (H6), and between FMS and FML (H7).

However, the results revealed that the implementation of BAT in the educational system does not moderate the positive relationship between FMS and ESP ($B = 0.091$, $t = 1.291$, $p = 0.197$). This indicates that BAT does not affect the positive relationship between FMS and ESP; hence, H5 is rejected.

Similarly, BAT does not moderate the positive relationship between FML and ESP ($B = -0.086$, $t = 0.731$, $p = 0.465$). This shows that BAT does not affect the positive relationship between FML and ESP, leading to the rejection of H6. Although BAT negatively affects the relationship between FML and ESP, the effect is not significant ($p = 0.465$).

Additionally, BAT does not moderate the positive relationship between FMS and FML ($B = 0.038$, $t = 0.731$, $p = 0.465$). This demonstrates that BAT does not affect the positive relationship between FMS and FML; hence, H7 is rejected.

The usual interpretation of *f*-square values is as follows: Minimal impact: $f^2 \geq 0.02$, Medium effect: $f^2 \geq 0.15$, Large impact: $f^2 \geq 0.35$. These thresholds help determine the practical significance of the interactions in the model. An *f*-square value less than 0.02 indicates minimal influence.

The Impact of the Independent Variable (IV) on the Dependent Variable (DV) without and with the moderating Effect—Effect Size of the moderator is explained as follows: The effect size statistic (*f*-square) showed no effect on all relationships, as indicated in **Table 8**. However, with the inclusion of the interaction effect, the R-squared value improved (**Table 9**). Despite this, the f-square values for all relationships remained below 0.02 (**Table 8**), indicating minimal influence. This suggests that the interaction has no moderating effect on ESP (Chen et al., 1998).

Table 8. F-square results.

	***f*-square**
3. Biometric Tech. (BAT) × 2. Loyalty (FML) → 4. Education Performance (ESP)	0.007
3. Biometric Tech. (BAT) × 1. Satisfaction (FMS) → 2. Loyalty (FML)	0.003
3. Biometric Tech. (BAT) × 1. Satisfaction (FMS) → 4. Education Performance (ESP)	0.007

Table 9. R-square with moderator (BAT) and without moderator.

	R-square (BAT)	**R-square**
2. Loyalty (FML)	0.514	0.509
4. Education Performance (ESP)	0.438	0.428

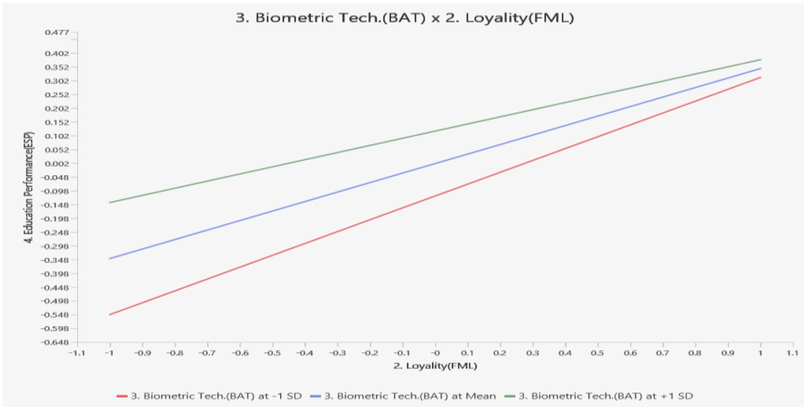


Figure 10. Slope analysis: Biometric Tech (BAT) × Loyalty (FML) → Education Performance (ESP) = 0.007.

The usual interpretation of f-square values is as follows: The red line represents minimal impact: $f^2 \geq 0.02$. The green line represents the medium effect: $f^2 \geq 0.15$. The blue line represents a large impact: $f^2 \geq 0.35$. From **Figure 10**, we can conclude that a low level of the moderator BAT, with minimal influence, negatively affects the relationship between ESP and FML. As mentioned earlier, there is no significant moderation level, so this slope analysis is generally not performed. However, we provide this analysis to offer a clearer picture of the effect size. The *f*-square value shows f^2: Biometric Tech (BAT) × Loyalty (FML) → Education Performance (ESP) = 0.007. Such a threshold result indicates a minimal influence, as the *f*-square value is less than 0.02.

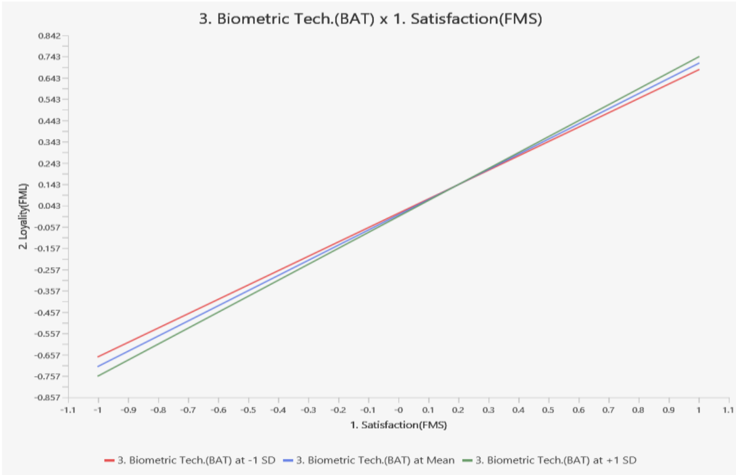


Figure 11. Slope analysis: Biometric Tech. (BAT) × Satisfaction (FMS) → Loyalty (FML) =0.003.

From **Figure 11**, we can conclude that a low level of the moderator BAT weakens the relationship between FMS and FML. Low level of BAT, which will negatively affect FML. As mentioned earlier, there is no significant moderation level, so this slope analysis is generally not performed. However, we provide this analysis to offer a clearer picture of the effect size. The f-square value shows f^2: Biometric Tech. (BAT) × Satisfaction (FMS) → Loyalty (FML) = 0.003. Such a threshold result indicates a minimal influence, as the f-square value is less than 0.02.

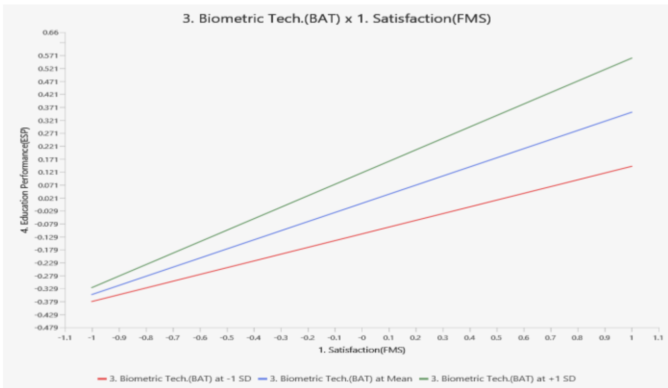


Figure 12. Slope analysis: Biometric Tech. (BAT) × Satisfaction (FMS) → Education Performance (ESP) = 0.007.

From **Figure 12**, we can conclude that a low level of the moderator BAT weakens the relationship between FMS and ESP. high level of BAT, which will positively affect ESP as we increase the FMS. As mentioned earlier, there is no significant moderation level, so this slope analysis is generally not performed. However, we provide this analysis to offer a clearer picture of the effect size. The f-square value shows f^2: Biometric Tech :(BAT) × Satisfaction (FMS) → Education Performance (ESP) = 0.007. Such a threshold result indicates a minimal influence, as the f-square value is less than 0.02.

The slope analysis considering the interaction factor was not significant. Given the insignificance of the interaction effect, the slope analysis is not essential to demonstrate. However, to better understand the impact of BAT on the relationships between Biometric Tech (BAT) × Loyalty (FML) → Education Performance (ESP), Biometric Tech (BAT) × Satisfaction (FMS) → Loyalty (FML), and Biometric Tech (BAT) × Satisfaction (FMS) → Education Performance (ESP), we conducted the slope analysis.

The slope analysis presented in **Figures 10–12** revealed no significant relationships involving FMS, FML, and ESP. However, the results showed a minimal improvement in the R-square values: Loyalty (FML) increased from 0.509 to 0.514, and Education Performance (ESP) increased from 0.428 to 0.438 (**Table 9**) after implementing the Biometric Technology Attendance (BAT) moderator on all relationships related to the educational system performance (ESP).

4. Discussion

It is pertinent to understand the influence of the Biometric Attendance Technology (BAT) system on academic staff to comprehend its wider implications on organizational effectiveness. Adopting BAT systems is frequently viewed in Western nations as a way to improve productivity, lower absenteeism, and simplify administrative procedures. The Arab and Gulf areas, however, offer a distinct setting where organizational, social, and cultural norms have a substantial impact on how these technologies are perceived and used.

Traditional values and hierarchical structures dominate workplace dynamics in the Arab and Gulf countries (Sadriwala et al., 2024; Shannaq et al., 2024; Shannaq and Al Shamsi, 2024). Personal connections and loyalty are highly prized in this culture, and any technology intrusion is frequently examined to make sure it is consistent with these values (Shannaq et al., 2019; Shannaq et al., 2020; Shannaq et al., 2023). Though intended to increase productivity, the use of BAT systems may be seen as a challenge to the accepted standards of honesty and trust. Faculty members may resist and become dissatisfied if they believe the system compromises their personal and professional integrity.

Our theory implements BAT systems in the Gulf and Arab countries and projects a sophisticated strategy that takes these cultural sensitivities into account. It is crucial to strike a balance between the growth of technology and the maintenance of traditional values and interpersonal trust in the Arab and Gulf cultures. This is in contrast to Western societies where the major focus is on operational efficiency.

We propose that any detrimental effects on faculty satisfaction and loyalty might be lessened by combining BAT systems with culturally aware tactics. Enhancing acceptability and efficacy can be achieved, for example, by including faculty members in the decision-making process, communicating openly about the advantages and drawbacks of the technology, and integrating the system with current cultural traditions. With consideration for the distinct cultural environment of the Arab and Gulf areas, this study attempts to offer an all-encompassing framework of technology as well as human values. We aim to close the gap that exists between cultural preservation and technical innovation, which could eventually improve the effectiveness and long-term viability of educational institutions.

4.1. Significance of the study

The distinguishing factor in this study is the focus on the Arab and Gulf region's values and orientations as compared to Western societal values and orientations. The older generation of officials has historically prioritized strict adherence to attendance and absence policies, often emphasizing these procedures more than actual employee productivity, which has a negative impact on the overall effectiveness of the system.

Several studies such as Alhussain and Drew (2010), Abdullah et al. (2023) Bawack et al. (2023), Alhussain and Drew (2009) investigated the prevalent belief particularly propagated through social media—that most employees disagree with organizational policies enforcing verification and monitoring through modern technologies like digital attendance systems. Employees often feel that these mechanisms undermine their loyalty and integrity, believing that a focus on productivity would be more beneficial than an emphasis on monitoring systems. This widespread skepticism has led to doubts and heated discussions across various sectors, especially in educational institutions.

Based on the literature review, no previous study has addressed a topic similar to the current one. Most existing research, such as that by Obafemi et al. (2023), Jigjiddorj et al. (2019), Ateeq et al. (2023), Harzaviona and Syah (2020), Chen et al. (2022) have focused on the impact of loyalty and satisfaction on organizational performance, predominantly in non-educational settings. Few studies have specifically examined this issue within the Arab community, particularly in the Gulf region.

There is a gap in research investigating the impact of Biometric Attendance Technology (BAT) on the relationship between loyalty levels and the performance of educational institutions. No research has examined the effect of such technology on the relationship between satisfaction levels and educational performance, nor the impact of BAT on the relationship between satisfaction and loyalty in educational settings in the Gulf region.

This study is significant because it addresses these gaps, providing valuable insights for decision-makers. It develops effective monitoring and control procedures and strategies before investing in expensive technology systems that may negatively impact the performance of educational organizations. Conversely, hesitation in adopting monitoring and control technologies could also harm future performance due to intense market competition. Given this, this study will significantly aid decision-makers in making informed and effective decisions that enhance productivity and reduce potential risks. Finally, this study offers theoretical and practical insights that improve the use of technology in educational settings and other contexts.

4.2. Additional analysis and summary of the results

Using the resulting theories to measure Biometric Attendance Technology (BAT) as the moderator variable, the following hypotheses were proposed:

H5: While BAT does not significantly impact the relationship between Faculty Member Loyalty (FML) and Education System Performance (ESP), it suggests that efficient use through change management and awareness strategies could positively affect both Faculty Member Satisfaction (FMS) and ESP.

H6: BAT does not moderate the relationship between FML and ESP. However, it suggests that effective utilization through change management and awareness strategies could positively influence both FML and ESP.

H7: BAT does not moderate the relationship between FMS and FML. Nonetheless, it suggests that efficient use through change management and awareness strategies could have a favorable impact on both variables.

Overall, these hypotheses imply that while BAT may not directly moderate certain relationships, its effective implementation through strategic change management and awareness initiatives could enhance both faculty satisfaction and the performance of the educational system.

4.3. Study limitations and future research directions

This study provides insights into the impact of Biometric Attendance Technology (BAT) systems on faculty members at educational institutions, particularly in the Sultanate of Oman. To enhance the robustness and generalizability of the findings, several issues must be addressed.

1) Sampling Methodology: The study used a non-probability convenience sampling method via email, which could introduce selection bias. This method was chosen due to time constraints, but it limits the applicability of the results to a broader population. Consideration of a probability sampling method may be more effective for a representative sample of the academic population.

2) Response Rate: Out of 411 faculty members contacted, only 296 completed the survey, resulting in a 72% response rate. Despite this, non-response bias might still affect the conclusions. Future studies should aim to boost response rates through follow-up reminders and incentives for a more comprehensive understanding of faculty perspectives.

3) Geographical and Cultural Scope: The study focused on faculty in Oman, limiting its applicability to other regions with different cultural norms. Future research should expand to include users from other Gulf nations and Western regions. Comparing feedback from these diverse contexts will provide a more comprehensive understanding of BAT systems’ impact.

4) Self-Reported Data: Reliance on self-reported data may introduce response bias. Future research should incorporate mixed methods, such as qualitative interviews or focus groups, to gain deeper insights and validate quantitative findings.

5) Limited Variable Scope: The study examined one dependent variable (ESP) and three independent variables (FML, FMS, and BTA). Future research should explore additional factors, such as faculty attitudes towards technology, organizational support, and specific features of the BAT system, to better understand their impact on BAT effectiveness.

Future research directions:

1) Comparative Analysis across Regions: Ongoing projects should include faculty from different Gulf and Western regions. Comparing feedback will help identify cultural and geographical differences in BAT systems’ acceptance and effectiveness, providing insights into aligning these systems to various contexts.

2) Longitudinal Studies: Future research should adopt a longitudinal approach to examine the long-term impacts of BAT systems on faculty satisfaction, loyalty, and educational performance. This provides clarity on how perceptions and outcomes evolve.

3) Integration of Qualitative Methods: It would be insightful to include qualitative methods, such as interviews and focus groups. This provides a richer understanding of faculty experiences and perceptions, uncovering nuances that quantitative data alone may not reveal.

4) Broader Range of Variables: Expanding the scope of the future study to include factors like organizational support, faculty attitudes towards technology, and specific BAT system features could provide a more comprehensive understanding of the determinants of successful BAT implementation.

5) Experimental Studies: Future research could design experimental studies to test the impact of different implementation strategies on faculty acceptance and performance. This could involve piloting various approaches to change management, training, and communication to identify the most effective methods for integrating BAT systems in educational institutions.

In conclusion, addressing these limitations and pursuing the outlined future research framework will enhance the understanding of BAT systems' impact on faculty members and bridge the gap across different cultural contexts and values. This will ultimately contribute to more effective and culturally sensitive implementation strategies, at the same time optimizing the benefits of BAT systems in educational settings.

5. Conclusion

The influence of Biometric Attendance Technology (BAT) on educational systems in the Arab and Gulf areas is thoroughly analyzed in this paper. This study makes a distinct contribution to the body of literature by examining the relationship between automation technology and cultural factors—a frequently ignored research topic. We provide a framework for tailoring attendance management systems to improve organizational performance and user satisfaction by combining technology implementation with human-oriented viewpoints using a hybrid approach.

The results highlight the importance of cultural quirks when implementing BAT systems, especially in areas where traditional beliefs have a big impact on workplace dynamics. The empirical data emphasizes the necessity for policies that are in line with the unique social and cultural settings of the Arab and Gulf areas in addition to highlighting the advantages of BAT in terms of enhancing productivity and attendance tracking.

Additionally, this study provides better insights into how to integrate BAT systems optimally, balancing technology efficiency with human elements to educational leaders. The study also paves the way for a better understanding of biometric technologies in educational settings bridging the gap between technology and user experience.

In conclusion, the study contributes to a better understanding of BAT's function in learning settings by offering a new viewpoint and framework that combines cultural sensitivity with technical innovation. This represents a new foundation for further research and policy development targeted at optimizing the advantages of new technology in many cultural contexts.

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