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CONTENTS

GROWTH TRENDS IN ELECTRICITY CONSUMPTION IN UZBEKISTAN AND PROBLEMS OF MODERNIZING THE GRID INFRASTRUCTURE.....	20
Bobobekov Ergash Abdumalikovich	
DETERMINANTS OF THE INTENTION TO PARTICIPATE IN FAMILY TAKAFUL IN A PREMARKET SETTING: A STRUCTURED REVIEW OF THE EVIDENCE AND A CONCEPTUAL FRAMEWORK FOR UZBEKISTAN.....	24
Usmanov Nematjon Gulomovich	
TOURISM RESOURCE EFFICIENCY AND SUSTAINABLE REGIONAL SERVICE SECTOR DEVELOPMENT: AN EMPIRICAL ASSESSMENT OF UZBEKISTAN	40
Safarov Bahadirkhon Shaxriyrovich	
Toshkhujaev Mustafokhon Abduvosi ugli	
TERRITORIAL DISPARITIES IN EMPLOYMENT EFFICIENCY IN KHOREZM REGION: ASSESSMENT AND POLICY DIRECTIONS	47
Azadova Gulnoza Sardorbekovna	
ЦИФРОВАЯ ЭКОНОМИКА КАК ДРАЙВЕР ЭКОНОМИЧЕСКОГО РОСТА.....	55
Динара Ташевна Гафарова	
DIGITAL PLATFORM-BASED TRANSFORMATION OF ENTERPRISE E-COMMERCE SYSTEMS: FACTORS, EFFICIENCY AND DEVELOPMENT PROSPECTS	59
Tuychiyev Shavkatjon Shokirali o'g'li	
WAYS TO OPTIMALLY ORGANIZE AND IMPROVE DIRECT TAXATION IN UZBEKISTAN	68
Kadyrov Bahodir Kudratovich	
EFFICIENCY OF SMALL AND MEDIUMSIZED BUSINESS FINANCING BASED ON MUSHARAKAH: AN ANALYSIS OF OPPORTUNITIES AND RISKS.....	73
Kenjaeva Durdona Ravshan qizi	
СОВЕРШЕНСТВОВАНИЕ БЮДЖЕТНОГО УЧЕТА В РЕСПУБЛИКЕ УЗБЕКИСТАН В УСЛОВИЯХ ЦИФРОВИЗАЦИИ И УСИЛЕНИЯ ГОСУДАРСТВЕННОГО ФИНАНСОВОГО КОНТРОЛЯ	79
Джамбакиева Гулнора Сайфутдиновна	
ANALYSIS OF INDICATORS OF HUMAN CAPITAL UTILIZATION AND LABOR RELATIONS EFFICIENCY IN THE SMALL BUSINESS SECTOR	89
Ulugmuradova Nodira Berdimuradovna	
THE EFFECT OF MANDATORY IFRS ADOPTION ON EQUITY GROWTH OF UZBEK PUBLIC INTEREST ENTITIES (PIEs).....	96
Mokhirjon Shavkatov Omon o'g'li	
METHODS FOR ASSESSING THE IMPACT OF SMALL BUSINESS DEVELOPMENT ON NATIONAL ECONOMIC GROWTH.....	103
Akmaljon Adkhamovich Ermatov	
LEGISLATION AS AN ENABLER OF MARKET FORMATION: THE SIGNIFICANCE OF ADOPTING ISLAMIC BANKING PRINCIPLES FOR THE DEVELOPMENT OF ISLAMIC FINANCE IN UZBEKISTAN.....	111
Sultanov Bakhtiyor Bakhodirovich	
ANALYSIS OF REGIONAL INTEGRATION PROCESSES INTO FOREIGN MARKETS.....	117
Ozodova Farida Zarif kizi	
FINANCIAL INTENSITY AND YOUTH ENTREPRENEURSHIP IN UZBEKISTAN: EVIDENCE FROM A TWO-WAY FIXED-EFFECTS REGIONAL PANEL MODEL	122
Isakjanova Saboxat	

ENHANCING BIG DATA SOLUTIONS IN THE TOURISM INDUSTRY ECONOMIC EFFICIENCY AND FORECASTS INDICATORS.....	131
Temirov E.I.	
DEVELOPING AN AI-BASED CONTINUING MEDICAL EDUCATION SYSTEM: A COMPARATIVE ANALYSIS OF NATIONAL AND INTERNATIONAL SCHOLARLY APPROACHES	141
Nazarov Bakhrom Mustafayevich	
ADAPTIVE MANAGEMENT MECHANISM BASED ON A RESILIENT VALUE CHAIN FOR THE STRATEGIC SUSTAINABLE DEVELOPMENT OF AGROCLUSTER ACTIVITIES	147
Abdumalik Hakimovich Berdiyev	
INTERNATIONAL PRACTICE: TAX INCENTIVES FOR INVESTMENT	153
Fazliev Farrukh Fakhridinovich	
AN ANALYSIS OF LEADING FOREIGN BANKS' PRACTICES IN APPLYING ARTIFICIAL-INTELLIGENCE-BASED MANAGEMENT SYSTEMS FOR CREDIT RISK ASSESSMENT AND THE EARLY DETECTION OF PROBLEM LOANS.....	160
Alovuddin Jamolov	
DIGITAL FINANCIAL INCLUSION AS A DRIVER OF WOMEN'S ENTREPRENEURSHIP AND POVERTY REDUCTION: EVIDENCE FROM UZBEKISTAN	164
Ulashova Zarnigor Botirali qizi	
INDUSTRIAL DEVELOPMENT AND ENVIRONMENTAL SECURITY: THEORETICAL AND METHODOLOGICAL FOUNDATIONS FOR A REGIONAL ANALYSIS OF UZBEKISTAN.....	168
Erkaeva Bibirobiya Kamoladdin kizi	
PROSPECTS FOR THE USE OF GREEN FINANCE INSTRUMENTS IN FINANCING THE EXPORT ACTIVITIES OF ENTERPRISES	175
Turaeva Yulduz Shamsiddin qizi	
IMPROVING THE MANAGEMENT SYSTEM OF PRIVATE SCHOOLS BASED ON INNOVATIVE TECHNOLOGIES. METHODS USED: SEM, AHP.....	184
Shohida Esanova	

IMPROVING THE MANAGEMENT SYSTEM OF PRIVATE SCHOOLS BASED ON INNOVATIVE TECHNOLOGIES.

METHODS USED: SEM, AHP

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Abstract. This study examines the mediating role of technology integration in the relationship between innovative leadership and management effectiveness during the digital transformation of private schools. As educational technologies continue to develop rapidly, a wide range of digital management tools and innovative teaching systems are being introduced to address specific administrative needs in private education. The objective of the study is to provide empirical evidence on the capacity of innovative technologies to improve school management and to assess the effectiveness and priorities associated with this transformation.

The study applies structural equation modelling (SEM) and the Analytic Hierarchy Process (AHP). Schools with high technology-adoption scores in the SEM analysis and schools allocating greater expenditure to administrative technology categories that are not directly related to teaching activities in the AHP analysis are used as comparison groups. Drawing on a cross-sectional survey of more than 300 respondents, the study first examines aspects of the management system that may be considered efficient and innovative, particularly administrative coordination and data-driven decision-making.

The results indicate strong positive short-run associations between technology use and school management efficiency, as well as statistically significant relationships with staff productivity and service quality. These findings are consistent with the AHP-based assessment of schools' expenditure priorities for digital infrastructure. At the same time, although administrators generally perceive these technologies as useful and necessary for their professional activities, the findings also identify certain forms of organizational engagement that may be complex, costly, and demanding.

The integration of management functions through innovative technologies may contribute to improved outcomes for both administrators and teachers and may support the development of a management system that enhances educational quality. At the same time, the study highlights a potential tension between the technologies that appear effective for administrators in the short term and their possible long-term implications for the governance and sustainability of private schools.

Keywords: private school management, innovative technologies, technology integration, innovative leadership, management effectiveness, structural equation modelling, Analytic Hierarchy Process.

Аннотация. В данном исследовании рассматривается посредническая роль интеграции технологий во взаимосвязи между инновационным лидерством и эффективностью управления в процессе цифровой трансформации частных школ. В условиях стремительного развития образовательных технологий в частных образовательных учреждениях внедряется широкий спектр цифровых инструментов управления и инновационных систем обучения, направленных на удовлетворение конкретных административных потребностей. Цель исследования заключается в представлении эмпирических доказательств потенциала инновационных технологий в совершенствовании управления школой, а также в оценке эффективности и приоритетов, связанных с данной трансформацией.

В исследовании применяются моделирование структурными уравнениями (SEM) и метод анализа иерархий (AHP). В рамках SEM-анализа в качестве сравнительной группы рассматриваются школы с высокими показателями внедрения технологий, а в рамках AHP-анализа — школы, выделяющие более значительные средства на административные технологические направления, не связанные непосредственно с учебным процессом. На основе данных поперечного опроса более 300 респондентов в исследовании в первую очередь анализируются аспекты системы управления, которые могут

рассматриваться как эффективные и инновационные, в частности административная координация и принятие решений на основе данных.

Результаты показывают наличие сильной положительной краткосрочной взаимосвязи между использованием технологий и эффективностью управления школой, а также статистически значимых связей с производительностью персонала и качеством услуг. Эти результаты согласуются с оценками приоритетов расходов школ на цифровую инфраструктуру, полученными на основе АНР. В то же время, несмотря на то что администраторы в целом воспринимают данные технологии как полезную и необходимую часть своей профессиональной деятельности, исследование также выявляет отдельные формы организационного взаимодействия, которые могут быть сложными, затратными и требующими значительных усилий.

Интеграция управленческих функций посредством инновационных технологий может способствовать улучшению результатов деятельности как администраторов, так и преподавателей, а также развитию системы управления, поддерживающей повышение качества образования. Вместе с тем исследование выявляет потенциальное противоречие между технологиями, которые демонстрируют эффективность для администраторов в краткосрочной перспективе, и их возможными долгосрочными последствиями для управления и устойчивости частных школ.

Ключевые слова: управление частными школами, инновационные технологии, интеграция технологий, инновационное лидерство, эффективность управления, моделирование структурными уравнениями, метод анализа иерархий.

INTRODUCTION

School management systems and administrative leadership practices must increasingly address coordination challenges associated with digital transformation. As explored by McCarthy et al. [16], school leaders play an important role in managing the effects of technology on organizational performance. Technology integration can be understood as an organizational process through which administrators facing management problems receive timely information from digital systems to support decision-making [15]. The close relationship between technology adoption and the administrative and educational benefits generated by digital systems provides an important rationale for innovation and digital investment in the private-school sector [11].

The digitalization of administration aims, among other objectives, to improve school information management through faster communication, more integrated operations, greater transparency, financial monitoring, planning, and reporting [14]. However, the adoption of digital tools and systems in school management is not always successful. Financial constraints, weaknesses in technical infrastructure, insufficient readiness among school personnel, and limited organizational resources may constitute important barriers. Moreover, schools differ in their institutional capacities, and not all school leaders possess the same ability to plan, coordinate, and provide the support required to develop technological, financial, human, and organizational capabilities [4].

These conditions suggest that technology integration in private schools is more likely to be effective when digital tools designed specifically for administrative purposes are supported by both leadership and staff. Readiness to innovate, confidence in using technology, and the skills required to operate digital systems—collectively reflected in digital readiness—may help reduce the likelihood of disruption and inefficiency [8]. A number of studies support the view that digital management, compared with manual administration, can facilitate more efficient coordination, greater transparency, service development, informed decision-making, including financial and academic decisions, and communication among administrators and teachers [9]. Technology integration has also been associated with improvements in coordination, staff productivity, administrative transparency, and service quality, as well as reductions in paperwork [11, 14, 15]. Many systems supporting technology-based administration are primarily information-oriented [5, 12, 13]. One important development in the education sector over the past decade has therefore been the increasing use of information generated through technology to support management decisions, commonly referred to as data-based decision-making.

At the same time, some studies indicate that improvements in coordination, productivity, and service quality are not always consistent when highly digitalized schools are compared with less digitalized schools. To the best of our knowledge, one of the closely related studies examining the influence of management information systems on effectiveness is the Rawalpindi study based on evidence from privately managed schools. Technologies designed to assist school administrators continue to be investigated and developed [1]. This raises an important question: to what extent do digital systems generate information, coordination, and managerial insights that can be effectively communicated to administrators and teachers by school leaders?

The aim of this study is to develop a framework for evaluating the effectiveness of, and priorities associated with, the technological transformation of private schools. In particular, the study seeks to provide evidence on how this transformation has influenced the management system over several years following the introduction of digital technologies. This approach is consistent with McCarthy et al. [16], who emphasize “system change,” involving both leadership and technology, as a process underlying the development of digital education.

Further research is needed to deepen understanding of the effects of technology on private-school management and to support managerial decision-making [2, 4, 9, 11]. This study applies structural equation modelling to examine the relationships among innovative leadership, technology integration, and management effectiveness and compares the empirical findings with technology-investment priorities. The analysis is based on an empirical example from the private-school sector, where digital transformation has been accompanied by the modernization of management practices.

Based on the survey results, a structural model was developed to examine the indirect relationship between innovative leadership and management effectiveness through technology integration. The study covers the transformation period from 2021 to 2026 and is based on responses from members of private schools registered in Uzbekistan.

LITERATURE REVIEW

Previous studies have emphasized that digital technologies can improve school management by strengthening communication, coordination, monitoring, transparency, and data-based decision-making. McCarthy et al. [16] highlight the importance of leadership in managing digital transformation, while Oyier et al. [11] and Khan [15] show that ICT and management information systems can support administrative efficiency and decision-making in private schools.

Other studies indicate that the effectiveness of technology integration depends not only on the availability of digital tools but also on organizational readiness and the ability of school personnel to use them effectively. Forradellas et al. [4] emphasize the importance of digitalization strategies and institutional capacity, while Lia [8] shows that technology readiness is an important factor in the effective use of digital systems. Studies by Mbawala et al. [9] and Ramadani et al. [14] also demonstrate the role of information and financial management systems in improving coordination and administrative processes.

At the same time, existing research has mainly examined individual technologies, management information systems, or general effects of ICT adoption. Less attention has been given to the combined relationship among innovative leadership, technology integration, management effectiveness, and technology-investment priorities in private schools. Therefore, the present study applies Structural Equation Modelling (SEM) and the Analytic Hierarchy Process (AHP) to examine these relationships and identify the technology priorities most relevant to private-school management.

RESEARCH METHODOLOGY

The study employed a quantitative, cross-sectional survey design to examine technology integration, innovative leadership, management effectiveness, and technology-investment priorities in private schools. The primary population of interest consisted of personnel working in private educational institutions registered with the relevant national authority. Given the objectives of the study, particular attention was paid to administrators, teachers, and technical staff with direct experience in the use of technologies within private-school management.

The online questionnaire was designed to be completed in less than 20 minutes and therefore consisted primarily of closed-ended items. Following a preliminary examination of the survey and administrative information, an additional questionnaire was distributed to school representatives to obtain supplementary responses on issues relevant to the study.

A total of 327 respondents participated in the survey. The sample covered the selected regions and included approximately 150 administrators, more than 100 teachers, and nearly 80 technical staff members. Respondents were selected on the basis of their experience in private-school management and technology use. Individuals primarily engaged in public-school administration and those with less than one year of experience in technology use were excluded from the analytical sample. Incomplete questionnaire responses were also excluded from the statistical analysis. These selection criteria were intended to ensure that the respondents had sufficient direct experience with technology integration in private-school settings.

Access to the respondent group was approved by the group administrator, who also served as the research coordinator. Members were informed about the study through an announcement posted on the group page, and participation was based on responses to the online questionnaire.

The research dataset consisted of two main components. The first comprised cross-sectional questionnaire data on technology integration in private-school management, which were used for Structural Equation Modelling (SEM). The second consisted of pairwise-comparison judgments concerning technology-investment priorities, which were analyzed using the Analytic Hierarchy Process (AHP). Information on school technology investments was also incorporated into the prioritization analysis.

AHP is an established decision-making method used to determine the relative weights, priorities, and preferred alternatives within a structured decision problem (Saaty, 1980). In the present study, the pairwise-comparison instrument was administered to selected private-school respondents to assess the relative importance of alternative technology investments.

The technological transformation examined in the study covered the period 2021–2026, corresponding to the period during which the selected schools introduced and expanded the use of digital technologies. The technologies considered included student information systems, financial software, electronic attendance systems, communication platforms, learning management systems, and reporting systems. The transformation process was considered in three broad stages: (i) initial technology preparation, (ii) gradual system implementation, and (iii) integrated technology use.

The SEM analysis focused on the relationships among three principal constructs: innovative leadership, technology integration, and management effectiveness. Management effectiveness was measured through indicators related to administrative coordination, staff productivity, transparency, service quality, and data-based decision-making. Technology integration was measured by combining the scores of relevant questionnaire items into a composite index.

The measurement model specified the observed indicators associated with each construct, while the structural model estimated the direct and indirect relationships among the latent variables. The indicators and constructs were examined during pilot testing with participating schools. Particular attention was given to the indirect relationship between innovative leadership and management effectiveness through technology integration.

The AHP analysis was used to evaluate and compare technology-investment priorities. The alternatives considered included digital infrastructure, school information systems, financial software, communication platforms, staff training and maintenance, teaching platforms, hardware and software, data security, and technical support. Pairwise comparisons were used to determine the relative priority assigned to each alternative and to identify the areas considered most important for private-school management.

The two analytical approaches served complementary purposes. SEM was used to estimate the relationships among innovative leadership, technology integration, and management effectiveness, with the results expressed through standardized path coefficients. AHP was used to determine the relative priorities of technology-investment alternatives according to participants' judgments.

The survey responses relating to administrative coordination, staff productivity, service quality, and data-based decision-making were analyzed together with participants' assessments of technology-investment priorities. The SEM results were used to examine the direct and indirect relationships among the study constructs, while the AHP results provided evidence on the relative importance of alternative technology investments.

The combined use of SEM and AHP therefore made it possible to examine both the relationships among leadership, technology integration, and management effectiveness and the priorities associated with technology investment in private schools.

Table 1. AHP Priority Matrix for Innovative Technology Alternatives and Management Criteria in Private Schools

	Digital Management Platform	Integrated School Management System	Technology Training and Support Model	Cost and Financial Feasibility	Management Efficiency	Service Quality and Transparency	Staff Digital Readiness	Goal
Digital Management Platform	0.00000	0.00000	0.00000	0.73750	0.06601	0.09091	0.61533	0.30198
Integrated School Management System	0.00000	0.00000	0.00000	0.08522	0.61533	0.18182	0.31866	0.08964
Technology Training and Support Model	0.00000	0.00000	0.00000	0.17728	0.31866	0.72727	0.06601	0.10838

Cost and Financial Feasibility	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.30066
Management Efficiency	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02628
Service Quality and Transparency	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.05336
Staff Digital Readiness	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.11971
Goal	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 2. Final AHP Ranking of Innovative Technology Alternatives in Private-School Management

Rank	Alternative	Ideals	Normals	Raw
1	Digital Communication and Coordination Platform	1.000000	0.603959	0.301980
2	Technology Training and Technical Support Model	0.358901	0.216761	0.108381
3	Integrated School Management Information System	0.296841	0.179280	0.089640

Table 3. Structural Equation Modelling Results for Technology Integration and Management Effectiveness in Private Schools

	Coef.	Std.Err.	z	P>z	[95%Conf.	Interval]
Structural						
digital_readiness_index						
school_id	0.009	0.003	2.590	0.010	0.002	0.016
region_code	0.117	0.170	0.690	0.490	-0.216	0.450
_cons	69.075	0.940	73.450	0.000	67.232	70.918
data_based_decision_maturity						
region_code	-0.109	0.088	-1.240	0.214	-0.281	0.063
role_code	0.047	0.209	0.220	0.823	-0.363	0.456
_cons	57.925	0.540	107.190	0.000	56.866	58.984
technology_integration_index						
role_code	1.563	0.229	6.830	0.000	1.115	2.011
innovative_leadership_index	0.671	0.045	14.880	0.000	0.583	0.760
_cons	17.949	3.444	5.210	0.000	11.199	24.698
interoperability_friction_score						
digital_readiness_index	-0.257	0.039	-6.550	0.000	-0.334	-0.180
data_based_decision_maturity	0.021	0.071	0.290	0.771	-0.119	0.161
staff_productivity_gain	-0.313	0.065	-4.790	0.000	-0.442	-0.185
service_quality_index	-0.175	0.068	-2.570	0.010	-0.309	-0.041
_cons	89.181	3.098	28.790	0.000	83.110	95.252
workflow_automation_depth						

data_based_decision_maturity	-0.098	0.060	-1.640	0.102	-0.216	0.020
technology_integration_index	0.585	0.064	9.090	0.000	0.459	0.711
management_effectiveness_score	0.203	0.070	2.910	0.004	0.066	0.340
service_quality_index	-0.041	0.055	-0.740	0.457	-0.149	0.067
_cons	10.702	2.148	4.980	0.000	6.492	14.913
var(e.digital_readiness_index)	34.267	2.680	29.397	39.943		
var(e.data_based_decision_maturity)	9.194	0.719	7.888	10.717		
var(e.technology_integration_index)	7.253	0.567	6.222	8.454		
var(e.interoperability_friction_score)	4.302	0.336	3.691	5.015		
var(e.workflow_automation_depth)	2.756	0.216	2.364	3.213		

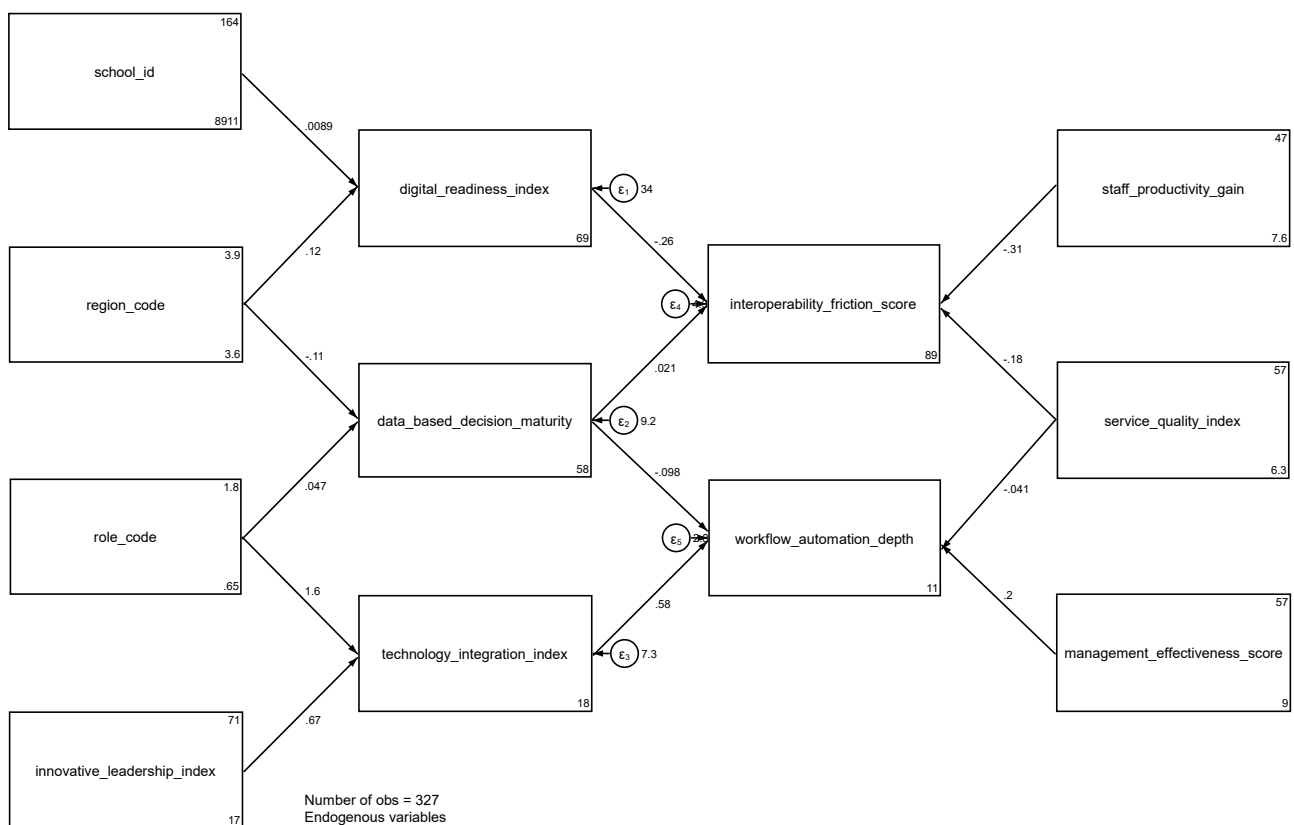


Table 4. SEM Model Fit Statistics for Technology-Based Private School Management

Fit statistic	Value	Description
Likelihood ratio: chi2_ms(31)	1605.675	Model vs. saturated
p > chi2	0.000	Statistical significance of model-saturated comparison
Likelihood ratio: chi2_bs(45)	2429.937	Baseline vs. saturated
p > chi2	0.000	Statistical significance of baseline-saturated comparison

ANALYSIS AND RESULTS

The SEM results indicate that digital readiness, data-based decision maturity, technology integration, interoperability friction, and workflow automation are significantly associated with several management-related conditions in the surveyed private schools. Five estimated coefficients were statistically significant at the 1% level and one coefficient was statistically significant at the 5% level. The structural relationships examined included school identification and digital readiness, respondent role and technology integration, innovative leadership and technology integration, digital readiness and interoperability friction, staff productivity and interoperability friction, service quality and interoperability friction, technology integration and workflow automation, and management effectiveness and workflow automation. Several of the remaining paths were not independently statistically significant.

In particular, region did not significantly predict either digital readiness or data-based decision maturity. Respondent role did not significantly predict data-based decision maturity, while data-based decision maturity did not significantly predict either interoperability friction or workflow automation.

As shown in Table 3, innovative leadership had a strong positive and statistically significant association with technology integration ($\beta = 0.671$, $p < 0.001$). Respondent role was also significantly associated with technology integration among the surveyed private-school personnel. These results suggest that stronger innovative leadership is associated with a greater degree of integration of digital systems into administrative coordination and information-processing activities.

The SEM estimates further show that higher levels of technology integration were associated with greater workflow automation. Greater digital readiness was associated with lower interoperability friction, while staff productivity and service quality were also negatively associated with interoperability friction. According to the estimated confidence interval, a one-unit increase in the digital-readiness index was associated with an estimated reduction in the interoperability-friction score ranging from approximately 0.180 to 0.334 points. This result should be interpreted as a cross-sectional association rather than as a temporal effect over the 2021–2026 period.

The structural path linking innovative leadership to technology integration was statistically significant ($\beta = 0.671$, $z = 14.880$, 95% CI: 0.583–0.760, $p < 0.001$). Technology integration was also positively associated with workflow-automation depth. Based on an estimated coefficient of 0.585 and a standard error of 0.064, the 95% confidence interval ranged from approximately 0.459 to 0.711. These estimates reflect associations derived from cross-sectional survey responses and should not be interpreted as longitudinal effects.

The moderating effect of respondent role on the relationship between innovative leadership and technology integration was not directly tested. However, the estimated coefficient for respondent role indicates that respondents from different occupational categories reported significantly different levels of technology integration. The strong association between innovative leadership and technology integration therefore remained evident across the estimated structural model, although the cross-sectional design does not allow conclusions regarding whether these relationships changed over time.

Similarly, no interaction term between innovative leadership, respondent role, and transformation phase was estimated. Consequently, the statistical significance of such an interaction cannot be determined from the present model. Regional differences in digital readiness and data-based decision maturity were statistically insignificant and relatively small, providing no clear evidence of a regional pattern.

The robustness assessment based on the confidence intervals of the estimated structural paths indicates that, when the relationship between innovative leadership and technology integration is interpreted as associative rather than causal, the estimated relationships involving workflow automation and interoperability friction remain consistent with the main findings reported in Table 3.

The AHP results presented in Tables 1 and 2 indicate clear differences in technology-investment priorities. The **Digital Communication and Coordination Platform** received the highest normalized priority weight of **0.603959**, followed by the **Technology Training and Technical Support Model** with **0.216761** and the **Integrated School Management Information System** with **0.179280**. These results identify stakeholder preferences regarding technology investment but do not establish year-specific changes or causal effects over the 2021–2026 period.

Several of the estimated structural relationships are statistically significant and substantively meaningful. Overall, the results indicate a strong positive association between innovative leadership and technology integration, while the relationship with data-based decision maturity is less pronounced. The findings also indicate that greater digital readiness is associated with lower interoperability friction.

Many surveyed administrators, teachers, and technical staff reported being relatively prepared to engage with the digital transformation and familiar with the technologies adopted by their schools. At the same time, some respondents reported lower levels of preparedness, while certain schools continued to face technical and financial constraints similar to those identified in previous research [4, 8]. The benefits of technology integration were not uniform across all respondent groups. However, regional affiliation did not significantly explain differences in digital readiness or data-based decision maturity.

The estimates indicate that a one-unit increase in the digital-readiness index was associated with an approximately 0.180–0.334 point reduction in interoperability friction within the estimated confidence interval. However, the cross-sectional design does not provide sufficient evidence to identify year-specific changes in management outcomes during the first or second year following technology adoption. The available evidence therefore supports a positive association between technology integration and workflow automation and a negative association between digital readiness and interoperability friction, rather than a temporal causal interpretation.

These findings suggest that school personnel who are more digitally prepared, more confident in using adopted systems, and more organizationally capable of integrating technology may be better positioned to limit interoperability problems. In this study, digital readiness reflects the confident and effective use of digital systems, technical competence, and organizational adaptability. These capabilities may support communication, information-based decision-making, and responsible technology use. Consequently, the organizational outcomes associated with digital systems appear to depend considerably on users' readiness to work with them.

The findings are consistent with previous research emphasizing the interaction between leadership and technology during digital transformation [16]. The strong positive coefficient linking innovative leadership with technology integration is also consistent with earlier evidence on ICT integration, coordination, and school-management quality [9, 11, 15]. However, because the dataset does not contain longitudinal observations, the present study cannot determine whether interoperability friction declined over time after implementation.

The results further suggest that digital readiness may contribute to reducing interoperability friction by limiting technical barriers and coordination difficulties. This interpretation is consistent with previous studies in which technology integration was identified as an important link between innovative leadership and organizational effectiveness [3, 16]. Technology training may therefore represent an important component of professional development during digital transformation, while continued technical and administrative support may also be necessary for sustained system use.

Although differences in research design and measurement prevent direct comparison with earlier studies [9, 11, 15], the present findings are broadly consistent with previous evidence that digital technologies can reduce administrative burdens and strengthen coordination. The AHP results reinforce this interpretation: the **Digital Communication and Coordination Platform** received the highest stakeholder priority, suggesting a particularly strong preference for technologies that improve communication and management coordination during digital transformation.

Respondent role was not tested as a moderator of the relationship between innovative leadership and technology integration. Nevertheless, occupational category was significantly associated with reported levels of technology integration. This suggests that technology use may vary across administrators, teachers, and technical staff, even though the available model does not establish a moderating effect.

Several limitations should be acknowledged. First, the analysis is based on self-reported, cross-sectional survey data and therefore does not provide a longitudinal view of the transformation process. Second, the use of survey measures for both explanatory and outcome variables may introduce common-method bias. Third, the lack of longitudinal or experimental data limits the causal interpretation of the estimated relationships between technology integration and school-management outcomes. Accordingly, the SEM results should primarily be interpreted as evidence of statistically significant structural associations rather than causal effects.

CONCLUSION AND SUGGESTIONS

The findings of this study have practical relevance for school leaders, administrators, teachers, and technology providers involved in organizing and managing the digital transformation process. The results highlight the importance of understanding technology integration within a balanced organizational context and moving beyond overly simplified views of technologies as either beneficial or harmful, or as simply efficient or inefficient.

School leaders considering the introduction of digital systems should also take into account the broader implications of these technologies for school management. Accordingly, administrators, teachers, technical staff, technology providers, and policymakers should consider the organizational consequences of the increasing use of digital technologies, particularly digital communication and coordination platforms.

Given the cross-sectional nature of the dataset, the present study was unable to conduct longitudinal comparisons. Future longitudinal research should therefore examine year-specific changes in management effectiveness and organizational sustainability in private schools. Nevertheless, the present analysis shows that the digital transformation process is closely associated with the technology-investment preferences reported by stakeholders in the surveyed schools.

Future studies should also seek to establish causal relationships between technology integration and management effectiveness using longitudinal research designs or experimental methods. Particular attention should be given to whether the aspects of technology integration that were associated with higher management effectiveness in the present study can produce similar outcomes in schools where personnel have lower levels of digital readiness or where organizational conditions are less favorable to digital transformation.

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