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Determinants of Learning Outcomes in Mathematics Education: Analyzing Internal and External Factors in the Society 5.0 Context

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ABSTRACT

The emergence of Society 5.0, characterized by the integration of advanced digital technologies into all aspects of life, poses new challenges and opportunities in education. Understanding how internal and external factors affect student learning outcomes within this context is critical, particularly in mathematics education where self-regulation and technology use are essential. This study employed a sequential explanatory mixed-methods design to investigate the influence of internal (learning motivation, self-regulated learning, self-management) and external (digital learning quality, technological infrastructure, environmental support, lecturer competence) factors on learning outcomes in the Society 5.0 era. A total of 240 undergraduate mathematics education students participated in the quantitative phase, analyzed using SEM-PLS, followed by in-depth interviews with 30 students for qualitative exploration. Quantitative findings revealed that internal factors, especially learning motivation, had the strongest influence on academic performance. Among external factors, digital learning quality was the most significant. The Society 5.0 construct, while significantly associated with learning outcomes, did not moderate the relationship between internal/external factors and academic achievement. Qualitative data reinforced the central role of motivation and self-management, while also highlighting additional influences such as psychological well-being, health, and socioeconomic status. These findings underscore that internal psychological factors remain the primary drivers of student success in digitally enhanced learning environments. External support and technological infrastructure play a complementary role. The results suggest a need for holistic educational strategies that balance technological integration with student-centered development.

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1. INTRODUCTION

The emergence of the Society 5.0 trend has led to indirect implications that enable Indonesia, as a developing country, to play a proactive role in preparing for the future trajectory of this transformative

era (Daffa Faqiha Fawwaz Hanjowo et al., 2023; Rohayati & Abdillah, 2024). In the Society 5.0 era, characterized by the integration of the physical and digital worlds, profound changes occur across all aspects of life, including education (Maulidya & Indriani, 2024; Sugiarto & Farid, 2023). Higher education institutions, as one of the key entities contributing to the educational sector in Indonesia, must possess the capability to adapt to various emerging trends, including those driven by Society 5.0 (Daffa Faqiha Fawwaz Hanjowo et al., 2023; Suharyati et al., 2024). The primary focus of education has shifted from mere knowledge acquisition to the development of adaptability, creativity, and critical thinking skills (Loughland, 2019; McKinnon, 2013). The rapid transformation of the educational environment ranging from the use of advanced technologies to evolving social structures has reshaped the ways in which students acquire, process, and apply knowledge (Bondac & Hrestic, 2023; Scott, 2023).

Education serves as a fundamental pillar of national progress (Khurana, 2014; Mehnatfar, 2012; Pal, 2023; Vetrova et al., 2022). The quality of education provided by higher education institutions plays a pivotal role in shaping the future of younger generations and, more broadly, in influencing a nation's economic growth (Jovanović, 2023). Students' academic achievements are a primary indicator of educational system effectiveness (Manurung, 2017). However, behind every score or accomplishment lie numerous factors that shape students' learning outcomes. Therefore, understanding the factors that affect students' learning outcomes is essential for optimizing learning processes in the Society 5.0 era and ensuring that each student can achieve their fullest potential.

Research on the factors influencing students' learning outcomes has gained significant attention in recent years. These factors are generally categorized into internal and external domains. Internal factors include discipline, learning motivation, self-management, and adaptability to learning environments (Hapsari & Vanadian, 2022). Such factors positively influence students' learning outcomes as they enhance performance and engagement in the learning process (Fazriansyah, 2023; Fazriansyah et al., 2025; Sajirun et al., 2022; Sobandi & Nurlatifah, 2019). On the other hand, external factors such as lecturer competence, teaching variation, internet connectivity, and learning environment also play vital roles in shaping students' academic performance (Hamilton, 2019). These factors may either support or hinder learning outcomes depending on their effectiveness and accessibility.

Although various studies have examined factors influencing student learning outcomes, most have focused on traditional or pre-digital educational contexts, overlooking the unique challenges and dynamics introduced by the Society 5.0 era. Prior research has generally analyzed internal factors or external factors in isolation rather than as an integrated system shaped by technological and social transformation. Moreover, few studies have contextualized these factors within a framework that captures how digital learning ecosystems, driven by automation, artificial intelligence, and ubiquitous connectivity, reshape students' learning behaviors and outcomes. Consequently, there remains a significant gap in understanding how internal dispositions and external supports interact in influencing students' academic performance in the Society 5.0 context—where adaptability, digital competence, and self-management are increasingly essential for success. This research seeks to address this gap by examining both internal and external determinants of learning outcomes through a holistic and technology-aware lens.

To address these gaps, this study integrates three key theoretical frameworks. Self-Determination Theory (SDT) provides a foundation for understanding intrinsic and extrinsic motivation that drives students' engagement and persistence in learning (Ryan & Deci, 2000). Heutagogy, or self-determined learning, offers a perspective on how learners develop autonomy, adaptability, and self-management in digitally mediated environments (Hase & Kenyon, 2013). Meanwhile, the Technology Acceptance Model (TAM) explains how perceived usefulness and ease of use of digital platforms influence learners' acceptance of and engagement with technology-enhanced learning (Davis, 1989). By integrating these frameworks, the study conceptualizes students' learning outcomes as a multidimensional construct

influenced by motivational, self-regulatory, and technological factors each interacting dynamically within the educational ecosystem of Society 5.0.

Furthermore, to achieve a deeper and more contextualized understanding, this study employs a mixed-method approach with a sequential explanatory design, where quantitative analysis identifies significant relationships among factors, followed by qualitative exploration to interpret and enrich the findings. This design enables a holistic understanding of how internal dispositions and external supports jointly shape learning effectiveness.

Based on the aforementioned background, the objectives of this study are to determine the influence of learning motivation, self-regulated learning, self-management, digital learning quality, environmental support, technological facilities, and lecturer competence in the Society 5.0 era on students' learning outcomes, and to further examine how technological advancements, rapid social changes, and emerging educational trends in the Society 5.0 era affect the factors that shape students' academic performance in this digital age. The study contributes to educational research by providing an integrative model that links motivation, autonomy, and technology acceptance to student performance offering both theoretical advancement and practical implications for designing adaptive, technology-enhanced learning strategies aligned with the demands of Society 5.0.

2. METHODS

This study employed a mixed-methods approach using a sequential explanatory design, which integrates quantitative and qualitative analyses within a single research framework. In this design, the quantitative phase is conducted first, followed by the qualitative phase to strengthen, expand, and deepen the findings, as well as to uncover potential new insights (Wipulanusat et al., 2020). The use of a mixed-methods sequential explanatory design is theoretically grounded in the pragmatic paradigm, which emphasizes methodological pluralism to address complex educational problems. This approach integrates the strengths of both quantitative and qualitative methodologies. Quantitative methods provide measurable patterns and relationships, whereas qualitative methods uncover the meanings and contextual nuances behind those patterns. Theoretically, this combination enables the study to capture both breadth and depth of understanding regarding factors affecting student learning outcomes. Practically, the sequential structure allows the quantitative phase to guide the qualitative phase, ensuring that interview questions are informed by statistical results. This sequential linkage enables the researcher to explore why certain internal or external factors are more influential than others, providing richer and more actionable interpretations. The design therefore enhances the study's explanatory power and strengthens the validity of its conclusions by allowing data from one phase to complement and elaborate upon the other. The quantitative phase involved the administration of a structured questionnaire to identify significant predictors of learning outcomes, while the qualitative phase utilized semi-structured interviews to provide deeper insights into the quantitative findings.

The quantitative phase involved 240 participants, comprising students from mathematics education programs located in both the City and Regency of Tasikmalaya. The sample size was determined using the Slovin formula with a margin of error (e) of 5%. For the qualitative phase, participants were selected through a snowball sampling technique, involving 30 students who provided more in-depth perspectives to complement the quantitative results.

The research instrument consisted of a structured questionnaire designed to measure three main constructs: internal factors, external factors, and the influence of the Society 5.0 era on students' learning outcomes. Internal factors included indicators of learning motivation, self-regulated learning, and self-management. External factors covered digital learning quality, technological facilities, environmental support, and lecturer competence. The Society 5.0 construct measured students' perceptions of technological development, social change, and educational trends in the digital era.

Data analysis in this study was conducted through complementary quantitative and qualitative approaches. The quantitative data were analyzed using the Structural Equation Modeling–Partial Least Squares (SEM-PLS) method with the assistance of SmartPLS 4 software. This method was selected for

its capability to examine complex relationships among latent variables, test the validity and reliability of measurement instruments, and its suitability for studies with a moderate sample size.

Table 1. SEM-PLS Analysis

Evaluation Model	Unit of Analysis	Criteria
Outer Model	Outer Loading	> 0.70
	Composite reliability	> 0.70
	Cronbach's alpha	> 0.70
	Average Variance Extracted (AVE)	> 0.50
	Fornell-Larcker criterion	AVE of the laten constructs should be higher than any other latent construct
Inner Model	P-value	< 0.05
	R^2-value	0.75; 0.50; 0.25 (Substantial, Moderate, Weak)
	Q^2-value	> 0

Source: (Hair, 2009, 2014; Hair Jr et al., 2023)

The validation of qualitative data in this study was carried out through direct member checking to ensure the credibility and accuracy of the findings. After the interview sessions were completed and the data were transcribed, the researcher conducted direct confirmation with participants regarding the preliminary interpretations of their responses. Feedback obtained from the participants was used to refine, adjust, or reaffirm findings. This direct member checking procedure strengthened the trustworthiness, accuracy, and authenticity of the qualitative data by minimizing researcher bias and ensuring that the results truly reflected participants' experiences and viewpoints.

Meanwhile, the qualitative analysis was conducted using data obtained from semi-structured interviews, analyzed through a thematic analysis approach. The process involved transcribing the interview data, reducing and organizing the information, coding relevant segments, grouping them into categories or emerging themes, and drawing conclusions in the form of descriptive narratives. Subsequently, the results of both the quantitative and qualitative analyses were integrated through data triangulation. This integration aimed to strengthen the overall research findings, confirm the consistency between quantitative and qualitative results, and provide a more comprehensive understanding of the factors influencing the learning outcomes of mathematics education students.

3. FINDINGS AND DISCUSSION

3.1 Finding

The results of the quantitative analysis using Structural Equation Modelling–Partial Least Squares (SEM-PLS) are presented in two main stages, namely the outer model and the inner model assessments. In the outer model stage, the analysis was conducted to ensure that the indicators employed in this study were both valid and reliable in measuring their respective latent variables.

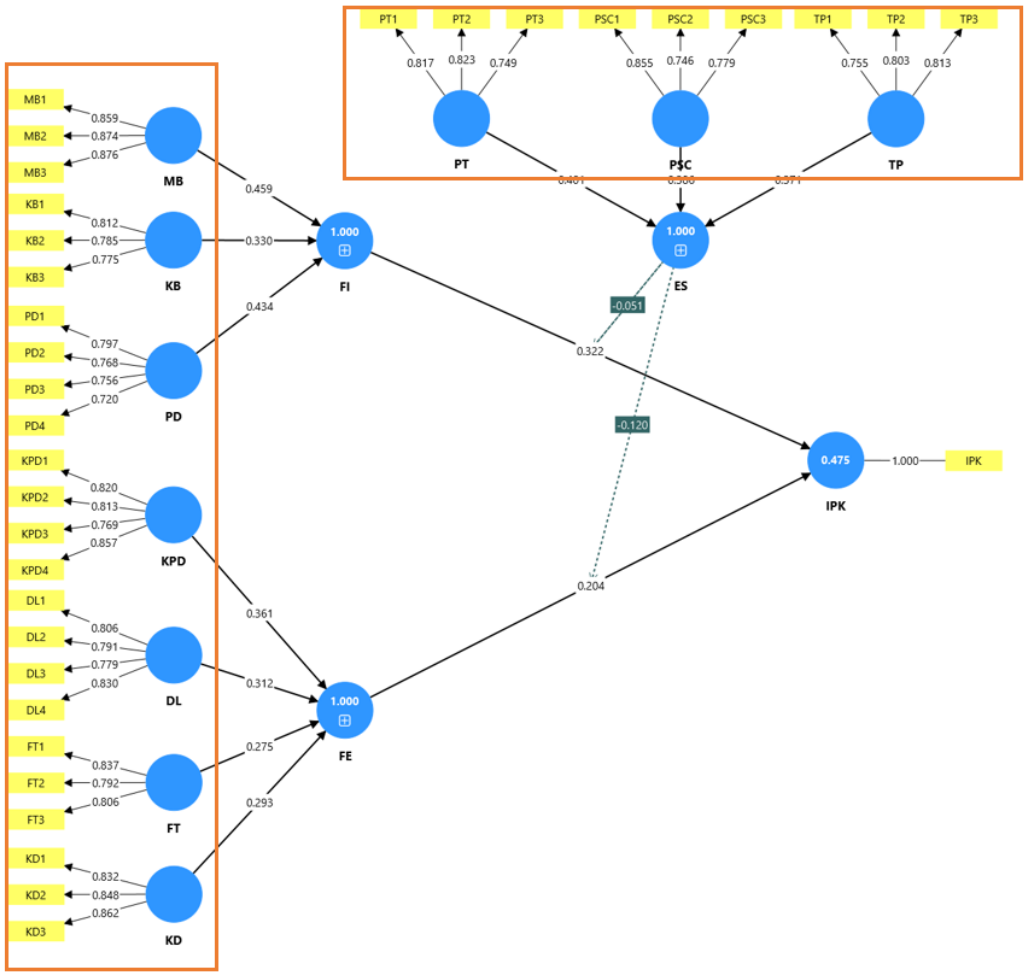

Figure 1. Outer Loading First-Order

As illustrated in Figure 1, all first-order indicators demonstrate loading factor values exceeding 0.70, indicating that each indicator is valid in measuring its respective dimension. In addition to representing the item validity of each indicator, the loading factor values also reflect the magnitude of each indicator's contribution to its corresponding construct.

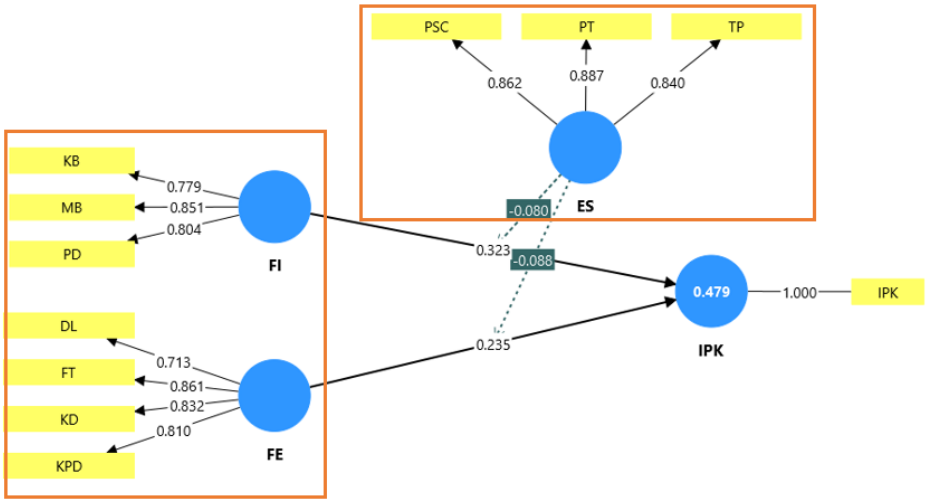

Figure 2. Outer Loading Second-Order

As shown in Figure 2, all dimensions of the second-order construct exhibit loading factor values greater than 0.70, indicating that all three dimensions are valid components forming the second-order construct. Values exceeding 0.70 signify a strong and consistent contribution of each dimension. The results that meet these criteria demonstrate that the second-order construct is well represented by its underlying dimensions, thereby confirming that the research model is valid and appropriate for measuring more abstract and complex concepts.

Table 2. Results of Reliability and Convergent Validity

	Code	Cronbach's alpha	Composite reliability	AVE
First-Order				
Learning Motivation	MB	0.839	0.903	0.756
Self-Regulated Learning	KB	0.701	0.833	0.625
Self-Management	PD	0.757	0.846	0.579
Quality of Digital Learning	KPD	0.832	0.888	0.665
Environmental Support	DL	0.815	0.878	0.643
Technological Facilities	FT	0.742	0.853	0.659
Lecturer Competence	KD	0.805	0.884	0.718
Technological Development	PT	0.711	0.839	0.635
Rapid Social Change	PSC	0.707	0.837	0.632
Educational Trends	TP	0.703	0.833	0.625
Second-Order				
Internal Factors	FI	0.743	0.853	0.659
External Factors	FE	0.819	0.881	0.650
Society 5.0 Era	ES	0.829	0.898	0.745

Source: Output SmartPLS 4

As presented in Table 2, all Average Variance Extracted (AVE) values are greater than 0.50, indicating that convergent validity has been satisfactorily achieved. Furthermore, the Composite Reliability (CR) and Cronbach's Alpha (CA) values exceed 0.70, demonstrating a high level of internal consistency among the measured constructs.

Table 3. Fornell-Larcker Criterion

	First-Order										
	MB	KB	PD	KPD	DL	FT	KD	PT	PSC	TP	IPK
MB	**0.870**										
KB	0.453	**0.791**									
PD	0.551	0.470	**0.761**								
KPD	0.537	0.516	0.347	**0.816**							
DL	0.577	0.348	0.406	0.510	**0.802**						
FT	0.584	0.293	0.371	0.559	0.502	**0.812**					
KD	0.540	0.353	0.304	0.579	0.379	0.659	**0.847**				
PT	0.397	0.352	0.331	0.502	0.361	0.644	0.565	**0.797**			
PSC	0.480	0.358	0.378	0.443	0.384	0.569	0.562	0.667	**0.795**		
TP	0.510	0.385	0.374	0.463	0.526	0.572	0.528	0.633	0.552	**0.791**	
IPK	0.568	0.475	0.427	0.443	0.413	0.535	0.527	0.440	0.462	0.439	**1.000**

	Second-Order			
	FI	FE	ES	IPK
FI	**0.812**			
FE	0.667	**0.806**		
ES	0.571	0.740	**0.863**	
IPK	0.610	0.600	0.518	**1.000**

Source: *Output SmartPLS 4*

The discriminant validity test using the Fornell–Larcker criterion presented in Table 3 shows that the square root of the Average Variance Extracted (AVE) for each construct is greater than the

correlations among the constructs. This finding indicates that each latent variable is well distinguished from the others. Therefore, it can be concluded that the research instrument demonstrates good convergent validity, discriminant validity, and reliability, and is thus appropriate for proceeding to the inner model evaluation stage.

The evaluation of the inner model was carried out by analyzing the path relationships among latent constructs through the coefficient of determination (R^2), which reflects the extent to which the variance of the endogenous variables can be explained by the exogenous variables (Hair, 2014).

Table 4. Coefficient of Determination

	R Square Adjusted
IPK	0.465

Source: Output SmartPLS 4

As presented in Table 4, the Adjusted R Square value for Learning Outcomes (IPK) is 0.465, indicating that 46.5% of the variance in learning outcomes can be explained by internal and external factors, which reflects a moderate effect size.

To further assess the predictive relevance of the model, the Q^2 value was examined. According to Chin (1998) and Hair (2009), a Q^2 value greater than zero signifies that the model possesses good predictive capability, indicating that the observed data are well represented by the proposed structural model.

Table 5. Q Square Value

	Q Square
IPK	0.424

Source: Output SmartPLS 4

Table 5 shows that the Q^2 value exceeds the minimum threshold of 0, indicating a strong predictive relevance with a predictive capability for learning outcomes of 0.424. Thus, it can be concluded that this study demonstrates good observational quality.

The statistical significance of the relationships among latent constructs is determined by a P-value less than 5%, while the magnitude of the influence between latent constructs is assessed using the Path Coefficient (Hair, 2014).

Table 6. Path Analysis

	Path Coefficient	P-Values	Decision
First-Order			
MB→FI	0.459	0.000	Significant
KB→FI	0.330	0.000	Significant
PD→FI	0.434	0.000	Significant
KPD→FE	0.361	0.000	Significant
DL→FE	0.312	0.000	Significant
FT→FE	0.275	0.000	Significant
KD→FE	0.293	0.000	Significant
PT→ES	0.401	0.000	Significant
PSC→ES	0.386	0.000	Significant
TP→ES	0.371	0.000	Significant
Second-Order			
FI→IPK	0.323	0.000	Significant
FE→IPK	0.235	0.003	Significant
ES→IPK	0.158	0.046	Significant
FI x ES→IPK	-0.080	0.376	Not Significant
FE x ES→IPK	-0.088	0.278	Not Significant

Source: Output SmartPLS 4

The results presented in Table 6 indicate that all first-order constructs significantly influence their respective higher-order dimensions. Specifically, Learning Motivation (MB), Self-Regulated Learning

(KB), and Self-Management (PD) were found to have a significant effect on the Internal Factors (FI) construct, with a p-value of 0.000 < 0.05. This result confirms that students' intrinsic motivation, self-management, and self-regulation represent essential internal components that directly support learning achievement. Among these, learning motivation exhibited the highest contribution value (0.459), implying that motivated students are more likely to engage actively and persistently in the learning process, thereby achieving better academic outcomes.

Similarly, the External Factors (FE) construct was significantly influenced by the Quality of Digital Learning (KPD), Environmental Support (DL), Technological Facilities (FT), and Lecturer Competence (KD), each with a p-value of 0.000 < 0.05. This finding demonstrates that the learning environment plays a substantial role in determining students' academic performance. The dimension with the greatest effect was the quality of digital learning (0.361), followed by environmental support and lecturer competence. This result reflects that digital learning systems supported by appropriate infrastructure and guided by competent lecturers enhance student engagement and facilitate better comprehension of learning materials.

In the context of the Society 5.0 Era (ES) construct, the dimensions of Technological Advancement (PT), Rapid Social Change (PSC), and Educational Trends (TP) also showed significant effects, with p-values of 0.000 < 0.05. The dimension of technological advancement emerged as the most dominant (0.401), suggesting that students recognize technological innovation as the key driver of learning transformation in the Society 5.0 era. These results align with the notion that rapid technological progress, combined with evolving educational paradigms, shapes how students access, process, and apply knowledge in modern learning settings.

The second-order analysis further revealed that Internal Factors (FI) significantly influence Learning Outcomes (IPK) with a p-value of 0.000 < 0.05. Likewise, External Factors (FE) also had a significant effect (p-value = 0.003 < 0.05), while the Society 5.0 Era (ES) construct exhibited a smaller yet still significant influence (p-value = 0.046 < 0.05). These results demonstrate that both internal and external factors contribute to students' academic success, with internal factors exerting the strongest overall influence.

However, the moderating effect of the Society 5.0 Era was found to be insignificant. The moderation between Internal Factors (FI) and the Society 5.0 Era (ES) resulted in a p-value of 0.376 > 0.05, and the moderation between External Factors (FE) and the Society 5.0 Era (ES) produced a p-value of 0.278 > 0.05. This implies that although the Society 5.0 context directly influences learning, it does not amplify or reduce the effects of internal or external factors on academic performance.

Qualitative findings obtained through interviews corroborate these quantitative results. Students consistently emphasized that motivation, self-regulated learning, and self-management are the key elements determining their learning outcomes. They explained that maintaining self-discipline and intrinsic motivation is essential in managing distractions especially those arising from digital platforms. Furthermore, students recognized the importance of external factors such as competent lecturers, interactive digital platforms, and sufficient technological facilities in creating an engaging and effective learning environment.

The interviews also revealed other influential elements not directly measured in the quantitative model, including health, psychological condition, self-confidence, and economic status. Students reported that poor health, stress, or limited financial resources often hindered their concentration and participation in online learning. Conversely, self-confidence and emotional stability were seen as catalysts for improved academic performance.

3.2 Discussion

The quantitative results of this study provide compelling evidence that internal factors are the most dominant determinants influencing students' learning outcomes in the context of higher education, particularly in mathematics education. The constructs of learning motivation, self-regulated learning, and self-management exhibited the strongest path coefficients, indicating that internal

psychological mechanisms significantly determine students' ability to achieve academic success. This finding corroborates prior studies by Panadero (2017) and Schunk & Zimmerman (2011) who emphasized that self-regulated learners demonstrate higher persistence, autonomy, and metacognitive control, which are crucial for sustaining engagement in digital and hybrid learning environments characteristic of the Society 5.0 era. Likewise, Abah et al. (2022) and Rachmawati et al. (2024) confirmed that intrinsic motivation fosters self-discipline and adaptability, enabling students to navigate cognitive challenges and maintain academic consistency despite external stressors.

Moreover, the role of self-management in this study aligns with the perspective of Boekaerts (2010), who asserted that self-regulation integrates motivation and cognition in a goal-directed system, enabling learners to control their emotions and learning strategies. In mathematics education, Asnawati & Firmasari (2024) found that students with high self-management tend to approach problem-solving systematically and exhibit resilience when encountering difficult problems. Thus, internal psychological attributes are not only predictive of academic achievement but also reflective of adaptive learning behavior within a self-determined learning framework, which are foundational in human centered technological ecosystems envisioned by Society 5.0.

The influence of external factors, particularly digital learning quality and lecturer competence, was also statistically significant. The findings indicate that the learning environment especially the effective integration of multimedia tools, interactivity, and digital pedagogy plays a reinforcing role in enhancing comprehension and engagement. Zhang (2024) emphasize that well-designed digital ecosystems promote cognitive engagement, collaborative learning, and satisfaction. Similarly, Martin et al. (2020) highlight that lecturers' technological pedagogical competence (TPACK) is a crucial enabler of effective online learning. When lecturers demonstrate confidence and skill in technology use, students are more motivated to participate actively and emulate digital literacy behavior.

These findings also align with the broader theoretical stance of Vygotsky (1978) sociocultural learning theory, which posits that learning occurs through interaction with more capable others and mediated tools in this case, digital platforms and competent instructors. In the context of Society 5.0, the external learning environment serves as an essential scaffolding mechanism that supports but does not replace internal motivation and regulation.

However, an intriguing outcome emerged regarding the non-significant moderating effect of the Society 5.0 construct. While technological advancement and socio-digital transformation are defining characteristics of Society 5.0, their role did not statistically moderate the relationship between internal and external factors with learning outcomes. This result suggests that students perceive technological progress as a contextual background rather than a determinant variable. In line with Fukuyama (2018), Society 5.0 is envisioned not as a purely technological revolution but as a human-centered transformation emphasizing the synergy between digital innovation and human well-being.

One possible explanation for this non-significant moderation lies in students' adaptive normalization of technology as digital tools become ubiquitous; their novelty and influence on learning motivation diminish. Similar observations were made by Rohmah (2023), who found that in post-pandemic educational settings, technology is perceived as a baseline requirement rather than a motivational enhancer. Hence, while the Society 5.0 framework shapes the educational context, internal and external academic mechanisms remain the direct determinants of student success.

The qualitative findings complement and deepen the quantitative analysis by providing insight into students' lived experiences. The data revealed that internal readiness motivation, discipline, and independence emerged as the most salient contributors to academic success. Students consistently described that their persistence, emotional control, and self-directed effort were decisive factors in achieving strong learning outcomes. These findings align with Blaschke & Hase (2019), who introduced heutagogy (self-determined learning) as an approach that empowers learners to take ownership of their educational pathways through reflection, autonomy, and digital collaboration.

At the same time, external supports, including digital infrastructure, lecturer feedback, and peer collaboration, were perceived as necessary reinforcements rather than primary drivers. Students

emphasized that supportive lecturers who provided timely feedback, utilized interactive platforms, and facilitated collaborative discussions significantly enhanced engagement. This aligns with Aboagye et al. (2020) and Al-Fraihat et al. (2020), who found that institutional support and online interaction quality directly influence learners' satisfaction and performance in digital education.

The qualitative data also revealed emergent contextual dimensions beyond the predefined variables: health, psychological well-being, self-confidence, and economic stability. As highlighted by Maghfiroh et al. (2023) and Sidik et al. (2024), students' physical and mental well-being strongly affect their focus, emotional balance, and academic persistence. Ismiasih & Mustika (2024) also identified self-confidence as a core affective factor influencing students' willingness to engage in complex learning tasks, while Chen (2024) highlighted that financial constraints limit access to technology and learning resources, which may exacerbate digital inequality.

Additionally, Jenal et al. (2025) noted that family support and community encouragement play indirect yet significant roles in fostering students' motivation during online learning, echoing Bronfenbrenner (2005) ecological systems theory, where microsystem interactions (family, peers, educators) influence academic performance through emotional and social capital. Thus, learning outcomes are best understood as products of complex interrelations among psychological, social, and economic dimensions reflecting a holistic model of academic achievement in the digital age.

Integrating both strands of data, this study underscores that internal factors function as the core psychological drivers of learning success, external factors serve as reinforcing environmental supports, and the Society 5.0 context operates as a broader socio-technological framework that provides opportunities but does not fundamentally alter internal learning mechanisms. This finding extends theoretical discourse by suggesting that while the digital transformation of education modifies learning modalities, the essence of achievement remains rooted in self-regulation, motivation, and effective instructional design.

The non-significant moderating role of Society 5.0, therefore, should not be interpreted as a limitation but as evidence of the resilience of human learning mechanisms. Students' adaptability, intrinsic motivation, and self-regulation continue to function independently of the accelerating digitalization around them. This is consistent with Ryan & Deci (2000) Self-Determination Theory (SDT), which posits that autonomy, competence, and relatedness drive sustainable motivation factors that persist regardless of technological mediation.

In this sense, the findings reaffirm the need for a human-centered paradigm in digital education, as echoed by Ghosh & Kumar (2025) and Ina Wai (2025), emphasizing that the Society 5.0 vision should prioritize empowering learners through technology rather than replacing their cognitive autonomy. Therefore, educators and institutions should design pedagogical frameworks that balance digital integration with emotional, motivational, and social development, ensuring that technology acts as a catalyst for not a substitute to human learning.

In conclusion, this study contributes to the evolving discourse on learning in the Society 5.0 era by offering a comprehensive model that bridges quantitative validation and qualitative interpretation. It reveals that academic success is shaped by an interplay of internal self-regulatory mechanisms, supportive external ecosystems, and adaptive responses to technological change. The findings advocate for a holistic educational approach that strengthens psychological resilience, enhances digital pedagogical quality, and fosters equitable access to technology, ensuring that learners not only survive but thrive within the dynamic landscape of Society 5.0.

4. CONCLUSION

This study concludes that internal factors—particularly learning motivation, self-regulated learning, and self-management—play the most dominant role in determining students' learning outcomes in mathematics education. These factors shape students' engagement, persistence, and ability to manage academic challenges effectively, making them the primary drivers of achievement. External

factors, including the quality of digital learning, technological facilities, environmental support, and lecturer competence, also contribute by creating a supportive learning environment that strengthens students' internal capacities. The findings further indicate that the Society 5.0 era influences learning outcomes through technological advancement and digital learning opportunities, but it does not significantly moderate the relationship between internal and external factors and students' academic performance. Qualitative findings reinforce that motivation, independence, and high-quality digital instruction are perceived as key determinants of success, while aspects such as psychological well-being, self-confidence, health, and socio-economic background indirectly influence learning outcomes. However, this study has several limitations, including the use of a cross-sectional design that limits causal interpretation, the use of snowball sampling which may introduce sampling bias, and the relatively limited geographical scope that restricts the generalizability of the findings. Therefore, future research should employ longitudinal or experimental designs to examine the long-term relationships among these variables and involve more diverse and representative samples across different regions and academic disciplines. Additionally, further studies are recommended to expand the conceptualization of Society 5.0 by incorporating aspects such as AI literacy, digital ethics, and social innovation, as well as conducting comparative studies across educational contexts and cultures to strengthen the theoretical and practical understanding of factors influencing student learning outcomes.

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