



# Presenting a Structural Model of the Effect of E-learning on Academic Self-concept with the Mediating Role of Self-regulation Strategies in Lower Secondary School Students in Miandoroud

Samaneh. Raofifar<sup>1</sup>, Fatemeh Soghra. Sina<sup>2\*</sup>

<sup>1</sup> Department of Curriculum, Nek.C. Islamic Azad University, Neka, Iran

<sup>2</sup> Department of Educational Management, Nek.C. Islamic Azad University, Neka, Iran

\* Corresponding author email address: fa.sina@iau.ac.ir

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## ABSTRACT

**Objective:** This study aimed to examine the structural relationship between e-learning and academic self-concept with the mediating role of self-regulation among lower secondary school students.

**Methods and Materials:** This research employed an applied, descriptive-correlational design based on Structural Equation Modeling (SEM). The statistical population included all lower secondary school students in Miandoroud during the 2023–2024 academic year. Using the Krejcie and Morgan Table, a sample of 331 students was selected through stratified random sampling by gender. Data were collected via three standardized questionnaires: the E-learning Questionnaire (Watkins, Triner, & Lee, 1990), the Academic Self-concept Questionnaire (Yesen Chen, 2006), and the Self-regulation Questionnaire (Pintrich & De Groot, 1990). Reliability was confirmed through Cronbach's alpha (0.84, 0.89, and 0.86, respectively). Data were analyzed using AMOS and SEM with fit indices confirming the model adequacy.

**Findings:** E-learning had a significant positive effect on academic self-concept ( $\beta = 0.576$ ,  $t = 7.147$ ,  $p < 0.05$ ) and self-regulation ( $\beta = 0.814$ ,  $t = 17.929$ ,  $p < 0.05$ ). Self-regulation also had a significant positive effect on academic self-concept ( $\beta = 0.321$ ,  $t = 3.161$ ,  $p < 0.05$ ). Mediation analysis indicated that self-regulation partially mediated the relationship between e-learning and academic self-concept, as the indirect effect was statistically significant and the total effect exceeded 0.30.

**Conclusion:** E-learning enhances students' academic self-concept both directly and indirectly through strengthening their self-regulation. Developing students' self-regulatory strategies can maximize the benefits of digital learning environments and support positive academic self-beliefs.

**Keywords:** E-learning; self-regulation; academic self-concept; structural equation modeling; secondary school students

## 1. Introduction

The rapid evolution of digital technologies has fundamentally reshaped educational systems worldwide, offering unprecedented opportunities for learners to engage in more flexible, personalized, and autonomous learning experiences. E-learning has emerged as a transformative paradigm that transcends temporal and spatial constraints, fostering access to educational resources and enabling students to take ownership of their learning processes. In this context, two critical constructs—Self-regulation and Academic Self-concept—have garnered growing scholarly attention as central determinants of students' success within digital learning environments. Research has consistently highlighted the reciprocal interplay between e-learning engagement, the deployment of self-regulatory strategies, and the shaping of learners' academic self-beliefs, which collectively influence academic achievement, motivation, and emotional well-being (Bylieva et al., 2021; Oxford, 2016).

E-learning environments demand a high degree of learner autonomy, requiring students to regulate their cognition, motivation, and behaviors effectively in the absence of direct instructor supervision (K. Faridian et al., 2021; Hasani Jafari & Abbasi, 2020). According to Oxford (2016), self-regulated learning is characterized by learners' ability to set goals, monitor their progress, and adapt strategies to achieve learning outcomes. Within virtual classrooms, this self-directed approach becomes a vital predictor of students' engagement and persistence, as learners must actively plan, control, and evaluate their learning processes (Falakdin, 2021; McNaughton et al., 2023). Furthermore, self-regulation serves as a mediating mechanism through which students translate the affordances of e-learning platforms into meaningful academic outcomes, thereby bridging the gap between technological access and effective learning performance (Abedini, 2023; Kobra Faridian et al., 2021).

Alongside self-regulation, students' academic self-concept—a multidimensional perception of their academic abilities and competencies—plays a crucial role in shaping their motivation, effort, and achievement within digital settings (Puertos, 2022; Salman et al., 2024). Academic self-concept influences how students interpret challenges, persevere through difficulties, and evaluate their academic growth. Learners with higher academic self-concept are more likely to exhibit persistence and adaptive learning behaviors when confronted with the self-directed demands of e-learning environments (Haseli Songhori & Salamti,

2024; Kordi, 2021). Conversely, weak academic self-concept may undermine motivation and lead to disengagement, emphasizing the need to investigate factors that enhance this construct within online learning ecosystems (Emesi et al., 2024; Parsaei Doost et al., 2023).

Empirical studies have increasingly underscored the dynamic relationship between e-learning, self-regulation, and academic self-concept. For instance, McNaughton (2023) found that the implementation of school-wide digital learning programs had context-specific impacts on students' self-regulation, though not necessarily on social skills, illustrating the nuanced nature of digital interventions. Similarly, Faridian (2021) demonstrated that explicit training in self-regulation strategies significantly enhanced learners' readiness for e-learning, which in turn improved their self-directed learning behaviors. Complementing this, Hasani Jafari (2020) reported that students in electronic schools exhibited superior self-regulation skills and higher academic motivation compared to their counterparts in traditional schools, suggesting that digital learning contexts inherently promote self-regulatory capacities when appropriately scaffolded.

Moreover, the development of self-regulatory skills has been shown to mediate the relationship between students' motivational beliefs and their academic self-concept (Parsaei Doost et al., 2023). Janalizadeh (2023) also observed that exposure to e-learning tools promoted the use of metacognitive and cognitive self-regulated learning strategies, thereby fostering deeper cognitive engagement. Such findings align with Oxford's (2016) conceptualization of self-regulation as a cyclical process of forethought, performance, and self-reflection, which allows learners to optimize their learning outcomes. As learners practice self-regulation in digital settings, they not only improve their learning performance but also cultivate a stronger sense of academic competence, reinforcing their academic self-concept (Bylieva et al., 2021; Puertos, 2022).

The role of academic self-concept is particularly salient during the formative years of schooling, where students' beliefs about their academic abilities shape their motivation and engagement trajectories (Kordi, 2021; Salman et al., 2024). Positive academic self-concept contributes to greater academic resilience, self-efficacy, and persistence, which are essential for navigating the autonomous structure of e-learning environments (Emesi et al., 2024; Haseli Songhori & Salamti, 2024). In this regard, Moghami (2023) revealed that project-based e-learning significantly enhanced students' self-efficacy and academic engagement, which are

key components of self-concept development. Similarly, Lai (2021) found that learners' emotional experiences and self-efficacy were directly associated with their satisfaction and achievement in online learning during the COVID-19 pandemic, underscoring the affective dimensions of academic self-beliefs in virtual contexts.

However, despite the growing evidence on the benefits of e-learning, the successful translation of digital engagement into improved academic outcomes is contingent upon students' ability to regulate their learning effectively (K. Faridian et al., 2021; Razeghi & Saberi, 2017). Bylieva (2021) emphasized that students who lack self-regulatory skills are prone to procrastination, distraction, and cognitive overload in online settings, which can erode their academic self-concept and achievement. This suggests that self-regulation not only mediates the effect of e-learning on learning outcomes but also serves as a protective factor that sustains learners' academic self-concept against the potential challenges of digital environments. Accordingly, integrating self-regulation scaffolds into e-learning systems can empower students to manage their cognitive load, sustain motivation, and enhance their self-perceptions as competent learners (Abedini, 2023; Shariati et al., 2024).

Beyond individual learning outcomes, the interplay between e-learning, self-regulation, and academic self-concept has broader implications for educational equity and innovation. Shariati (2024) argued that the design of virtual education systems must consider principles of educational equity to ensure that students from diverse backgrounds can access the resources and supports needed to develop self-regulation and positive academic self-concepts. This perspective aligns with the findings of Haseli Songhori (2024), who demonstrated that students' academic engagement was strengthened through academic support systems mediated by psychological capital, suggesting that institutional structures can amplify the benefits of e-learning by fostering both self-regulation and self-belief. Furthermore, Moghami (2023) and McNaughton (2023) highlighted that context-specific design of e-learning interventions is critical, as learners' self-regulatory responses and academic self-concepts are shaped by cultural, pedagogical, and technological factors unique to their learning environments.

In light of these considerations, examining the structural relationship between e-learning, self-regulation, and academic self-concept among students is crucial for advancing both theoretical understanding and practical interventions. Understanding how self-regulation mediates

the influence of e-learning on academic self-concept can inform the design of targeted instructional strategies, digital platforms, and teacher training programs that cultivate autonomous, motivated, and confident learners. Furthermore, such research can contribute to developing policies that address disparities in digital learning readiness, ensuring that all students are equipped to leverage e-learning opportunities effectively (Janalizadeh et al., 2023; Shariati et al., 2024).

Overall, the convergence of empirical evidence underscores a compelling rationale for investigating the mediating role of self-regulation in the relationship between e-learning and academic self-concept. As digital learning becomes an enduring component of contemporary education systems, fostering students' self-regulatory skills and strengthening their academic self-concepts emerge as dual imperatives for maximizing the potential of e-learning.

## 2. Methods and Materials

### 2.1. Study Design and Participants

This study is applied in terms of its purpose and descriptive-correlational in terms of its method, based on the Structural Equation Modeling (SEM) approach, because its aim is to describe the conditions or phenomena under investigation and examine their correlations. The statistical population of this study consisted of all 525 primary school teachers in Neka who were teaching during the 2023–2024 academic year, selected based on statistics obtained from the Primary Education Deputy of the Ministry of Education of Iran in Neka. The sample size was determined using the Krejcie and Morgan Table (for determining sample size from a given population), and 222 participants were selected through stratified random sampling based on gender.

### 2.2. Measures

**a) Social Responsibility Questionnaire:** Developed by Carroll (1991) to measure social responsibility. This questionnaire includes 11 items based on a five-point Likert scale (from "very high" to "very low"). Scoring is as follows: very high = 5, high = 4, neutral = 3, low = 2, very low = 1. The total score ranges from 11 to 55, with a cutoff point of 33.

**b) Organizational Work Trust Questionnaire:** A standardized questionnaire developed by Pain (2003), consisting of 16 items and covering the dimensions of integrity and honesty, reliability, competence, and

organizational commitment. It is scored on a five-point Likert scale (strongly disagree = 1 to strongly agree = 5). The scoring range is as follows: 16–32 = low organizational trust, 32–48 = moderate organizational trust, and above 48 = very good organizational trust.

**c) Job Attitudes Questionnaire:** Developed by Superiity and Mishra (2010), consisting of 54 items measuring trust, motivation, commitment, skills, and knowledge, scored on a five-point Likert scale (very high to very low). Each item is scored from 1 to 5, giving a total score range of 54 to 270, with a cutoff point of 162. Subscale scores are calculated by summing the scores of the relevant items.

Since the questionnaires used in this study are standardized, their content validity was confirmed by the supervisor. To assess their reliability, 30 questionnaires were initially distributed among participants, and Cronbach's alpha coefficients were calculated as 0.87 for the Social Responsibility Questionnaire, 0.89 for the Organizational Work Trust Questionnaire, and 0.88 for the Job Attitudes Questionnaire, indicating acceptable reliability.

### 2.3. Data Analysis

For hypothesis testing, inferential statistics were applied using SEM based on the Partial Least Squares (PLS) approach through SmartPLS3 to examine the study hypotheses.

## 3. Findings and Results

Table 1 presents the descriptive statistics and bivariate correlations among the study variables. The results showed that students reported relatively high levels of e-learning ( $M = 3.84$ ,  $SD = 0.61$ ), self-regulation ( $M = 3.67$ ,  $SD = 0.58$ ), and academic self-concept ( $M = 3.92$ ,  $SD = 0.55$ ). As expected, e-learning was positively and significantly correlated with self-regulation ( $r = .64$ ,  $p < .01$ ) and academic self-concept ( $r = .58$ ,  $p < .01$ ). Moreover, self-regulation was also positively and significantly associated with academic self-concept ( $r = .61$ ,  $p < .01$ ). These correlations indicate that students who engaged more actively in e-learning reported stronger self-regulation strategies and higher academic self-concepts, supporting the hypothesized associations among the constructs.

**Table 1**

*Descriptive Statistics and Correlations Among Variables (N = 331)*

Variable	M	SD	1	2	3
1. E-learning	3.84	0.61	—		
2. Self-regulation	3.67	0.58	.64**	—	
3. Academic Self-concept	3.92	0.55	.58**	.61**	—

After specifying the measurement models to evaluate the conceptual model of the study and to determine the existence or absence of causal relationships between the research

variables, as well as to assess the goodness of fit of the observed data to the conceptual model, the research hypotheses were tested using SEM.

**Table 2**

*Fit Indices of the Conceptual Model*

Type of Index	Fit Criterion	Value	Acceptable Threshold	Result
Absolute Fit Indices	Chi-square (CMIN)	16.207		
	Degrees of Freedom (DF)	22		
	Significance Level (P)	0.000	Less than 0.05	Acceptable
Relative Fit Indices	Chi-square to Degrees of Freedom Ratio (CMIN/DF)	1.97	Between 1 and 5	Acceptable
	Root Mean Square Error of Approximation (RMSEA)	0.028	Below 0.1	Acceptable
	Goodness of Fit Index (GFI)	0.92	Above 0.9	Acceptable
	Adjusted Goodness of Fit Index (AGFI)	0.99	Above 0.9	Acceptable
	Normed Fit Index (NFI)	0.92	Close to 1	Acceptable
	Tucker-Lewis Index (TLI)	0.91	Above 0.9	Acceptable
	Incremental Fit Index (IFI)	0.99	Above 0.9	Acceptable
	Comparative Fit Index (CFI)	0.97	Above 0.9	Acceptable
	Relative Fit Index (RFI)	0.63	Above 0.6	Acceptable
	Parsimony Comparative Fit Index (PCFI)	0.64	Above 0.6	Acceptable

Parsimony Normed Fit Index (PNFI)

0.69

Above 0.6

Acceptable

As established in the previous section, since the data distribution was found to be normal (based on the Kolmogorov–Smirnov test), the correlations among the variables were tested using AMOS. To examine the causal relationships between the independent and dependent variables and to validate the overall model, SEM was employed. The analysis was performed using AMOS software. The output showed that the Chi-square to degrees of freedom ratio was less than 3, and the other fit indices confirmed the adequacy of the model fit.

After confirming the model, the significance of the hypotheses was tested using two indices: Critical Ratio (CR) and P. Based on a significance level of 0.05, the critical ratio must be greater than 1.96; any parameter lower than this is considered non-significant. P-values smaller than 0.05 indicate that the computed regression weights differ significantly from zero at the 95% confidence level. The table below summarizes the significance coefficients and the results of the tested hypotheses.

**Table 3**

*Results of the Hypotheses*

Predictor	→	Outcome	Estimate	S.E.	C.R.	P	Result
Academic Self-concept	→	Self-regulation	.670	.096	6.956	***	Supported
E-learning	→	Self-regulation	.292	.053	5.540	***	Supported

In the first hypothesis, it was proposed that e-learning affects students' academic self-concept. Statistical analysis between these two variables shows, based on table above, that the obtained P-value confirms this hypothesis at the 95% confidence level.

In the second hypothesis, it was proposed that e-learning affects students' self-regulation strategies. Statistical analysis between these two variables shows, based on Table 3, that the obtained significance P-value is less than 0.05, confirming this hypothesis at the 95% confidence level.

In the third hypothesis, it was proposed that self-regulation affects students' academic self-concept strategies. Statistical analysis between these two variables shows, based on the results, that the obtained significance P-value is less than 0.05, confirming this hypothesis at the 95% confidence level.

In this section of the study, a Multiple Regression Analysis was conducted on the data. The aim of this analysis was to determine the contribution and impact of the

independent variables in explaining and predicting changes in the dependent variable. If the primary task of science is considered to be explaining natural phenomena by discovering and studying the relationships among variables, then multiple regression is a general and effective method to achieve this objective.

**Direct Effect, Indirect Effect, and Total Effect**

When examining the relationship between two variables, both the direct and indirect effects of variables on each other must be calculated.

**Direct effect:** Represents the direct effect of variable X on variable Y ( $\beta$ ).

**Indirect effect:** Represents the effect of variable X on Y through another predictive variable Z. The relationship between X and Y is indirect when X affects Z, and Z subsequently affects Y.

**Total effect:** Direct effect + indirect effect.

**Indirect effect formula:** The product of the coefficients of each path ( $\beta_2 \times \beta_3$ ).

**Table 4**

*Direct and Indirect Effects of Variables*

Total Effect	Indirect Effect	Direct Effect	Path
$\beta_1 + (\beta_2 \times \beta_3)$	$\beta_2 \times \beta_3$	$\beta_1$	$X \rightarrow Y$
$\beta_3$	—	$\beta_3$	$Z \rightarrow Y$

If the total effect is less than 0.3, the observed correlation is not significant.

If the total effect is between 0.3 and 0.6, the correlation is considered desirable.



If the total effect is greater than 0.6, the correlation is considered highly desirable.

**Table 5**

*Testing the Mediating Hypotheses*

Hypothesis	Standardized $\beta$	Direct Effect ( $\beta$ )	Indirect Effect ( $\beta_2 \times \beta_3$ )	Total Effect ( $\beta_1 + \beta_2 \times \beta_3$ )	Path	Result
Effect of Self-regulation on Academic Self-concept	0.66	0.32	$(0.29 \times 0.20) = 0.058$	$0.32 + 0.058 = 0.38$	Self-regulation $\rightarrow$ Academic self-concept	Supported
Effect of Self-regulation on E-learning	0.29	0.29	$(0.29 \times 0.32) = 0.093$	$0.29 + 0.093 = 0.38$	E-learning $\rightarrow$ Self-regulation	Supported

As shown in the table above, since the total beta value for all variables was greater than 0.3, all the mediating hypotheses are supported.

**Table 6**

*Path Coefficients and t-values for the First Hypothesis*

Path	Path Coefficient	t-value	Test Result
E-learning $\rightarrow$ Academic self-concept	0.576	7.147	Supported

According to Table 6 and Figure 1, the effect of e-learning on students' academic self-concept has been estimated with a path coefficient of 0.576. Given that the t-value of this path is 7.146 (which is greater than 1.96) and the significance level is less than 0.05, this path coefficient is significant at the 0.05 error level. This means that e-

learning affects students' academic self-concept. In other words, an increase of one standard deviation in scores on the E-learning Questionnaire would lead to an increase of 7.146 standard deviations in scores on the Academic Self-concept Questionnaire.

**Table 7**

*Path Coefficients and t-values for the Second Hypothesis*

Path	Path Coefficient	t-value	Test Result
E-learning $\rightarrow$ Self-regulation	0.814	17.929	Supported

According to Table 7 and Figure 1, the effect of e-learning on students' self-regulation has been estimated with a path coefficient of 0.814. Given that the t-value of this path is 17.929 (which is greater than 1.96) and the significance level is less than 0.05, this path coefficient is significant at

the 0.05 error level. This means that e-learning affects students' self-regulation. This can be interpreted as: with an increase of one standard deviation in scores on the e-learning questionnaire, there will be an increase of 17.929 standard deviations in students' self-regulation scores.

**Table 8**

*Path Coefficients and t-values for the Third Hypothesis*

Path	Path Coefficient	t-value	Test Result
Self-regulation $\rightarrow$ Academic self-concept	0.321	3.161	Supported

According to the data in Table 8 and the information obtained from Figure 1, the effect of self-regulation on students' academic self-concept has been shown with a path coefficient of 0.321. Given that the t-value of this path is

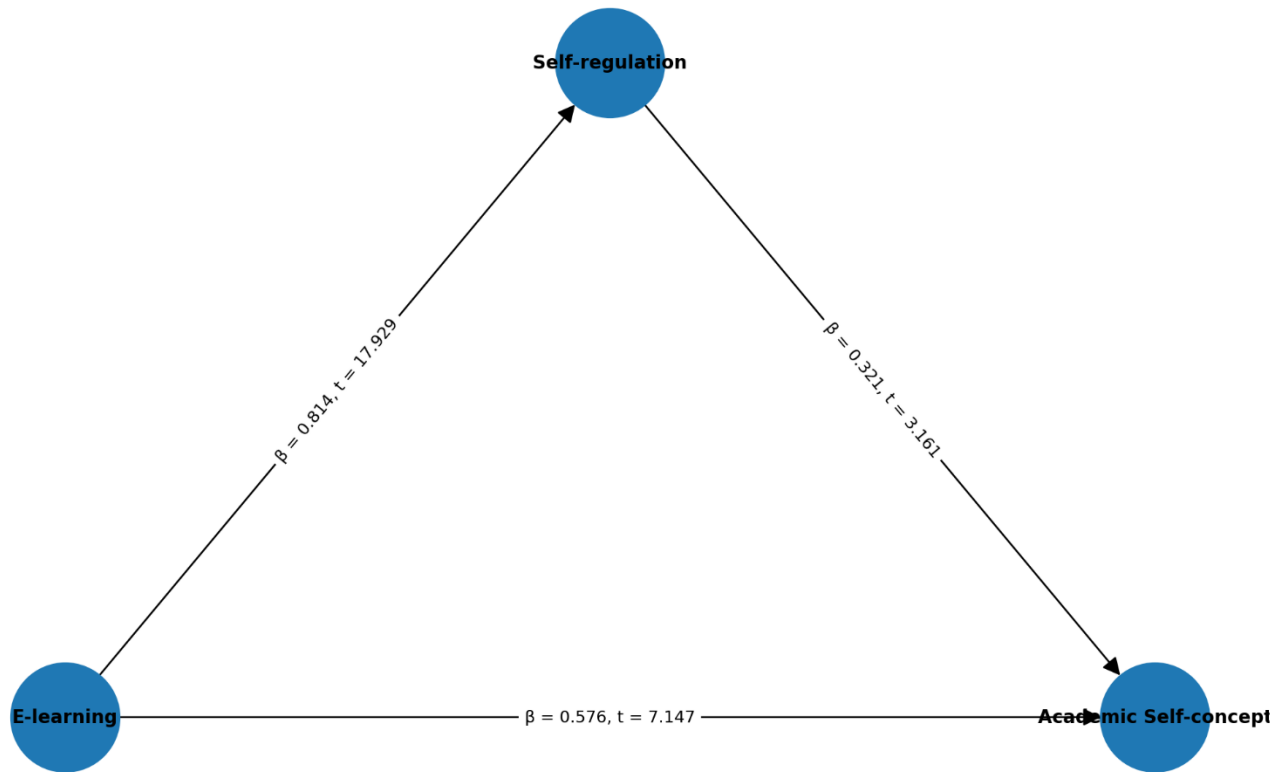
3.161 (which is greater than 1.96) and the significance level is less than 0.05, this path coefficient is significant at the 0.05 error level. This means that students' self-regulation affects their academic self-concept. Similar to the previous two

hypotheses, this can be interpreted as: with an increase of one standard deviation in scores on the Self-regulation

Questionnaire, there will be an increase of 3.161 standard deviations in students' academic self-concept scores.

**Figure 1**

*Final Model*



#### 4. Discussion and Conclusion

The present study examined the structural relationship between E-learning, Self-regulation, and Academic Self-concept, focusing on the mediating role of self-regulation among lower secondary students. The results showed that e-learning has a positive and significant effect on academic self-concept both directly and indirectly through self-regulation, and that self-regulation itself has a significant direct effect on academic self-concept. These findings are consistent with theoretical frameworks highlighting that digital learning environments can enhance learners' academic self-perceptions by fostering self-regulatory capacities, which subsequently influence their motivation and achievement (Bylieva et al., 2021; Oxford, 2016).

The direct positive effect of e-learning on academic self-concept observed in this study aligns with prior findings that digital platforms can enhance students' perceived competence when designed to offer autonomy, feedback,

and structured engagement opportunities. Research shows that students who engage meaningfully with e-learning are more likely to develop positive self-perceptions of their academic abilities (Kordi, 2021; Salman et al., 2024). E-learning offers interactive multimedia resources, immediate feedback, and flexible pacing, which allow students to experience mastery and thus strengthen their academic self-concept (Puertos, 2022). Lai (2021) further confirmed that emotional engagement and self-efficacy significantly predict satisfaction and achievement in online learning, indicating that digital contexts influence both cognitive and affective dimensions of academic self-concept (Lai et al., 2021).

The results also support the critical mediating role of self-regulation. Students who displayed stronger self-regulatory skills benefited more from e-learning and subsequently reported stronger academic self-concepts. This finding is consistent with the argument that self-regulation acts as a bridge between digital engagement and learning outcomes (Kobra Faridian et al., 2021; K. Faridian et al., 2021). As

Oxford (2016) conceptualizes, self-regulated learning involves cycles of forethought, performance, and self-reflection, and such cycles are fostered in autonomous e-learning environments. Bylieva (2021) also emphasized that self-regulated learners are less prone to distraction and procrastination, allowing them to sustain focus and motivation. These mechanisms explain why self-regulation mediates the impact of e-learning on academic self-concept (Bylieva et al., 2021).

The positive and significant direct effect of self-regulation on academic self-concept found here aligns with previous findings that self-regulatory skills shape learners' motivational beliefs and self-perceptions. Students capable of managing their time, monitoring progress, and controlling motivation are more likely to view themselves as competent and successful learners. Parsaie Doost (2023) reported that self-concept and motivational beliefs are closely associated with the use of self-regulation strategies, supporting this finding (Parsaei Doost et al., 2023). Likewise, Moghami (2023) showed that project-based e-learning enhanced students' self-efficacy and academic engagement, which are central to forming a positive academic self-concept (Moghami et al., 2023). Emesi (2024) also highlighted that self-worth and mental toughness predict academic achievement, suggesting that self-regulatory skills contribute to strengthening students' self-beliefs (Emesi et al., 2024). Similarly, Haseli Songhori (2024) demonstrated that academic engagement is reinforced through academic support systems mediated by psychological capital, which indirectly fosters students' self-concept (Haseli Songhori & Salamti, 2024).

Furthermore, the strong effect of e-learning on self-regulation in this study supports earlier findings that digital learning contexts inherently demand and develop self-regulatory skills. Hasani Jafari (2020) found that students in electronic schools had higher self-regulation skills and academic motivation than those in traditional schools (Hasani Jafari & Abbasi, 2020). Janalizadeh (2023) also observed that exposure to e-learning tools increased the use of metacognitive and cognitive self-regulated learning strategies, fostering deeper cognitive processing (Janalizadeh et al., 2023). McNaughton (2023) similarly reported that school-wide digital programs had positive context-specific impacts on self-regulation, indicating that the design of digital interventions influences their effect on learning behaviors (McNaughton et al., 2023). These findings suggest that when students engage with e-learning, they practice planning, monitoring, and evaluating their

learning, which enhances self-regulatory competencies over time.

Additionally, the present results support the perspective that well-designed e-learning systems can promote equity while fostering psychological and metacognitive skills. Shariati (2024) stressed that virtual education models must be designed with educational equity in mind to ensure that all students can benefit from e-learning opportunities (Shariati et al., 2024). Without such scaffolding, students may experience cognitive overload, which could erode self-concept even if they have technological access. Razeghi (2017) also highlighted that e-learning alone does not guarantee success unless accompanied by strategies that promote self-monitoring and metacognitive reflection (Razeghi & Saberi, 2017). Abedini (2023) likewise emphasized the importance of aligning learning objectives and assessment methods in e-learning systems to support self-regulated learning (Abedini, 2023). Together, these findings indicate that technology must be combined with instructional design aimed at nurturing self-regulation and self-concept.

The present findings also converge with the broader evidence that self-regulation evolves through iterative practice and feedback. Oxford (2016) argued that self-regulation develops dynamically as students interact with their learning environment (Oxford, 2016). This perspective is reinforced by Faridian (2021), who showed that self-regulation strategy training improves both e-learning readiness and self-directed learning (Kobra Faridian et al., 2021; K. Faridian et al., 2021). Salman (2024) similarly found that academic self-concept, academic resilience, and academic engagement together predict academic performance and are influenced by emotional self-regulation and self-esteem (Salman et al., 2024). These studies support the interpretation that self-regulation serves as a mechanism through which e-learning impacts both academic self-concept and achievement over time.

Taken together, the findings affirm a reciprocal and reinforcing relationship among e-learning, self-regulation, and academic self-concept. E-learning environments create opportunities for autonomy and personalized learning, which foster self-regulation, while successful self-regulation enhances students' academic self-concept, which in turn motivates further engagement in e-learning. This cyclical dynamic aligns with the broader theoretical models of self-regulated learning, which posit that motivation, metacognition, and self-beliefs operate in feedback loops that sustain academic achievement (Bylieva et al., 2021;



Oxford, 2016). Consequently, interventions seeking to improve students' academic outcomes through e-learning should simultaneously target the development of self-regulatory skills and the strengthening of academic self-concept. By doing so, educational systems can leverage the full potential of digital learning platforms to foster autonomous, confident, and resilient learners.

## 5. Limitations & Suggestions

Despite the valuable insights yielded by this study, several limitations must be acknowledged. First, the study employed a cross-sectional design, which precludes causal inferences about the directional relationships among e-learning, self-regulation, and academic self-concept. Although structural equation modeling can estimate the strength of relationships between variables, it cannot establish temporal precedence. Future longitudinal or experimental studies are needed to determine whether e-learning indeed causes changes in self-regulation and academic self-concept over time. Second, the data were collected through self-report questionnaires, which may be subject to social desirability bias or inaccurate self-assessment by students. Observational or performance-based measures of self-regulation and academic self-concept could provide more objective data. Third, the study focused on lower secondary school students in a specific geographic region, which may limit the generalizability of the findings to other educational levels or cultural contexts. Factors such as socioeconomic status, access to technology, and school-level support structures were not controlled, and these could influence the relationships examined. Finally, the study did not explore potential moderating variables such as gender, prior academic achievement, or emotional regulation, which may affect how e-learning relates to self-regulation and self-concept.

Future research could build upon this study in several ways. Longitudinal studies tracking students' development of self-regulation and academic self-concept over multiple semesters of e-learning would help clarify causal pathways and developmental trajectories. Experimental interventions that explicitly train self-regulation skills within digital environments could be implemented to examine their causal impact on both self-regulation and academic self-concept. Additionally, future studies could include a broader range of contextual variables, such as teacher support, parental involvement, and digital literacy, to understand how these factors moderate or mediate the relationships found in this

study. Cross-cultural comparisons could also be valuable for identifying cultural influences on self-regulation and self-concept formation in e-learning contexts. Furthermore, mixed-methods approaches that incorporate qualitative interviews or think-aloud protocols could provide richer insights into students' cognitive and emotional experiences as they engage in self-regulated e-learning. Finally, examining potential differential effects across demographic groups—such as by gender, socioeconomic status, or academic track—could inform targeted interventions for supporting diverse learners.

In practical terms, the findings suggest several strategies for educators and policymakers. Educational practitioners designing e-learning curricula should incorporate explicit instruction and scaffolds for self-regulation, such as goal-setting frameworks, progress monitoring tools, and reflective activities. Providing timely, formative feedback within digital platforms can reinforce students' sense of competence, thereby strengthening their academic self-concept. Schools and educational authorities should offer professional development for teachers to equip them with strategies to foster students' self-regulation and self-belief within online environments. Additionally, integrating motivational supports—such as opportunities for autonomy, choice, and peer collaboration—can sustain engagement and promote self-directed learning behaviors. Policymakers should ensure equitable access to technological resources and psychological support systems, so that all students have the conditions necessary to benefit from e-learning. Finally, embedding regular assessments of students' self-regulation and academic self-concept into digital learning systems can help educators identify at-risk students early and provide targeted support to enhance their learning outcomes.

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## Declaration of Interest

The authors of this article declared no conflict of interest.

## Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

## Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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## Authors' Contributions

All authors equally contributed to this article.

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