Contemporary Educational Technology, 2025, **17**(4), ep618
ISSN: 1309-517X (Online)

OPEN ACCESS

Research Article

Examining cognitive independence in the context of digital learning: A moderation analysis of student motivation, self-regulation skills, and cognitive engagement

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Citation: Ussenova, G., Issayeva, G., Urazaliyeva, R., Karimova, G., & Mukhanova, M. (2025). Examining cognitive independence in the context of digital learning: A moderation analysis of student motivation, self-regulation skills, and cognitive engagement. *Contemporary Educational Technology, 17*(4), ep618. https://doi.org/10.30935/cedtech/17570

ARTICLE INFO

Received: 23 Jul 2025
Accepted: 2 Dec 2025

ABSTRACT

This study investigates the extent to which the use of digital educational resources (DER) predicts students' cognitive independence (CI) in higher education and explores the moderating roles of psychological variables; motivation for digital learning, self-regulation skills (SRS), and cognitive engagement (CE). A total of 276 undergraduate students from Korkyt Ata Kyzylorda University in Kazakhstan participated in the study. Data were collected using a validated survey instrument covering five constructs: DER usage, motivation, self-regulation, CE, and CI. Moderation analyses were conducted using general linear models. The results revealed that DER usage is a significant positive predictor of CI. While motivation, self-regulation, and engagement were each strong direct predictors, only SRS and CE moderate the relationship between DER usage and CI. Specifically, students with lower levels of self-regulation or engagement benefited more from DER use. These findings show the compensatory role of digital tools in improving autonomy among less-prepared learners. The study contributes to the literature by identifying for whom DER is most effective and indicates the need for differentiated digital pedagogical strategies that promote independent learning.

Keywords: cognitive engagement, cognitive independence, digital educational resources, higher education, moderation analysis, motivation, self-regulation

INTRODUCTION

The increasing integration of digital educational resources (DER) into teaching and learning has transformed the way students engage with content, access information, and develop academic competencies (Fareen, 2022). These resources, ranging from multimedia platforms and interactive simulations to adaptive learning systems, present flexible and personalized learning experiences that extend beyond the traditional

classroom (Churchill, 2017). As digital learning environments grow in prominence, so do the expectations for learners to manage their studies independently, often with less direct supervision from instructors. This shift places a greater emphasis on the development of cognitive independence (CI), defined as students' ability to self-direct and regulate their learning processes (Guvercin, 2025; Zajonc et al., 2014).

CI refers to a learner's capacity to take ownership of the learning process by actively engaging in goal setting, planning, monitoring, and evaluating one's understanding and performance. It encompasses elements of metacognition, critical thinking, and decision-making, allowing students to operate autonomously without constant external guidance (Anderson, 2013). This form of independence is particularly important in digital and blended learning contexts, where learners often work asynchronously and are expected to regulate their pace and strategies. In such environments, CI is a desirable trait and it is essential for academic success (Bloshchynskyi et at., 2023). Learners with higher CI are better equipped to make sense of complex information, utilize digital tools effectively, and sustain motivation over time (Volkotrubova et al., 2024). Moreover, the development of CI aligns with the broader goals of 21st century education, which prioritize lifelong learning, adaptability, and the ability to learn how to learn (Churchill, 2017).

This study is grounded in three interrelated theoretical frameworks that explain how learners interact with DER: self-determination theory (SDT), self-regulated learning (SRL), and expectancy-value theory (EVT). SDT emphasizes the importance of fulfilling learners' basic psychological needs; autonomy, competence, and relatedness, to improve intrinsic motivation (Guay, 2022). In digital learning contexts, environments that support autonomy and provide meaningful feedback can increase students' motivation to engage independently with learning tasks (Jeno et al., 2017). Complementing this, SRL theory conceptualizes learning as a proactive process in which students set goals, monitor progress, and adapt strategies to achieve academic success (Zeidner & Stoeger, 2019). Digital platforms that include features such as learning dashboards, adaptive feedback, and goal-setting tools can scaffold these self-regulatory processes. Lastly, EVT explains how learners' motivation is influenced by their expectation of success and the perceived value of a task (Eccles & Wigfield, 2002). In digital environments, students who perceive DER as useful and aligned with their goals are more likely to engage in cognitively independent behaviors.

Despite a growing body of research on digital learning, several critical gaps remain in understanding how DER influence students' CI. While prior studies have explored the effects of DER on academic performance and engagement (Martin & Bolliger, 2018; Wong et al., 2025), fewer have investigated how DER contribute to the development of autonomous learning behaviors, such as goal-setting, strategic thinking, and self-monitoring. As educational environments become increasingly digital, there is a pressing need to understand whether DER are used, and how and under what conditions they support the development of cognitively independent learners (Camilleri & Camilleri, 2017; Rice et al., 2024).

The primary purpose of this study is to examine how the use of DER predicts students' CI in technology-enhanced learning environments. Specifically, the study aims to explore whether key psychological traits; motivation for digital learning (MDL), self-regulation skills (SRS), and cognitive engagement (CE), serve as moderators in this relationship.

Research Questions

1. To what extent does the use of DER predict students' CI?
2. Do psychological factors such as MDL, SRS, and CE mediate the relationship between DER usage and CI?

LITERATURE REVIEW

Cognitive Independence in Education

CI refers to a learner's ability to think critically, act autonomously, and regulate their own learning processes without constant external support (Anderson, 2013). Though often discussed under related constructs such as self-directed learning, learner agency, and autonomy, CI centers on an individual's sustained disposition to solve problems, manage intellectual tasks, and take responsibility for learning

outcomes (Okoń, 2005). This concept involves the integration of intellectual, emotional, and volitional capacities, allowing learners to approach academic tasks with initiative and persistence.

In digital and blended learning environments, CI is especially crucial. The shift toward online and technology-enhanced education requires students to self-regulate their learning, engage with content proactively, and navigate complex digital platforms independently (Shcherbina et al., 2017). Research highlights that the integration of media and information technologies supports the development of students' independence by enabling flexible access to content, improving communication, and encouraging personalized learning strategies (Rind et al., 2022). Moreover, when digital tools are embedded within adaptive e-learning systems, they can significantly enhance academic performance and reduce student resistance to independent tasks (Lavrov et al., 2021).

The development of CI is influenced by both developmental and contextual factors. Educational level, age, and prior experiences with autonomous learning contribute to a student's readiness for independent learning (Bloshchynskyi et al., 2023). In addition, institutional and instructional contexts, such as teacher practices, curriculum structure, and the integration of gamified or research-based activities play a significant role. Studies have shown that when students engage with real-world problem-solving tasks, gamified environments, or multimedia-based experiments, their independence and motivation improve significantly (García et al., 2021; Nilimaa, 2023). The creation of supportive educational settings, particularly those that incorporate forums, blogs, or self-paced modules, enhances learner control and decision-making capacity (Maygeldiyeva et al., 2020).

Furthermore, values and personal meaning assigned to the learning process also shape the trajectory of CI. A value-based approach that promotes intrinsic motivation and CE has been found to improve a deeper, more personalized form of independence in university students (Filippou et al., 2022).

DER and Learning Outcomes

DER encompass a broad spectrum of technology-based instructional materials designed to enhance teaching and learning processes. These resources include digital textbooks, interactive simulations, educational games, learning management systems, and multimedia content. DERs serve various purposes, such as delivering instructional content, facilitating student engagement, and supporting differentiated instruction to meet diverse learner needs. Integration of DER into educational settings allows for more personalized and flexible learning experiences, enabling students to access materials at their own pace and according to their individual learning styles (Churchill, 2017).

The implementation of DER has demonstrated significant impacts across cognitive, affective, and behavioral domains of student learning (Drozdikova-Zaripova & Sabirova, 2020; Wang et al., 2023). Cognitively, DERs can enhance understanding by providing interactive and visual representations of complex concepts, thereby facilitating deeper comprehension. Affective outcomes, such as increased motivation and engagement, are often observed when students interact with multimedia-rich and gamified learning environments. Behaviorally, the use of DERs encourages active participation and collaboration among students, increasing a more dynamic and interactive classroom atmosphere (Sun & Rueda, 2012).

DERs play a crucial role in promoting independent and self-directed learning by providing students with tools and resources that support autonomy in the learning process. Features such as adaptive learning pathways, immediate feedback, and access to a wide range of information empower students to take control of their educational journeys. The flexibility and accessibility of DERs enable learners to set their own goals, monitor progress, and adjust strategies to achieve desired outcomes, thereby increasing self-regulation and lifelong learning skills (Ifenthaler & Yau, 2020; Lee et al., 2014).

Motivation for Digital Learning

Motivation plays a foundational role in shaping students' engagement with digital learning environments (Sung & Huang, 2024). According to SDT, motivation exists on a continuum from extrinsic to intrinsic, and learners are more likely to succeed when their needs for autonomy, competence, and relatedness are met (Guay, 2022). In digital learning contexts, environments that support choice, self-pacing, and personalized feedback can enhance intrinsic motivation by improving a sense of control and relevance (Jeno et al., 2017).

EVT posits that learners' motivation is shaped by their expectations of success and the value they assign to the task (Eccles & Wigfield, 2002). In digital settings, the utility and perceived usefulness of digital resources influence students' decisions to engage. For instance, when students believe that using digital tools will contribute to their academic performance or future goals, they are more likely to invest effort and persist (Bi et al., 2024).

Motivation has been shown to influence a wide range of digital learning behaviors, including engagement, self-regulation, and task persistence. Intrinsically motivated students are more likely to explore course materials independently, use metacognitive strategies, and take ownership of their learning (Gennari & Valentini, 2024; Saxena, 2020). In contrast, externally regulated learners may engage superficially or disengage when extrinsic rewards or controls are removed. The structure of digital platforms, such as the presence of gamification, multimedia, and real-time feedback, can also stimulate motivational responses that affect how students navigate and interact with learning content (Zhang & Hashim, 2025).

Motivation is also strongly associated with learner autonomy, especially in online and blended learning environments where teacher presence may be reduced. Digital learning demands that students initiate and sustain learning efforts with limited external oversight, and motivation, particularly intrinsic motivation, is a critical predictor of such self-directed behaviors (Sukkamart et al., 2023).

Beyond being a direct predictor of learning behaviors, motivation frequently acts as a mediator or moderator in digital learning research. As a mediator, motivation often explains how instructional design features (e.g., interactivity, personalization, or relevance) influence learning outcomes. For example, personalization in a digital platform may improve learning because it enhances motivation, which in turn drives better engagement and performance (Gm et al., 2024). As a moderator, motivation can influence the strength or direction of relationships between variables such as digital tool use and cognitive outcomes. Students with high intrinsic motivation may derive greater benefits from digital tools, and those with low motivation may require scaffolding or external incentives (Qiao et al., 2022).

Self-Regulation in Digital Learning

SRL refers to learners' ability to actively control their cognitive, motivational, and behavioral processes to achieve academic goals. Two prominent models in SRL research are those proposed by Zimmerman (2002) and Pintrich (1995). Zimmerman's cyclical model comprises three phases: forethought (planning and goal setting), performance (self-monitoring and strategy use), and self-reflection (self-evaluation and adaptation). Pintrich's (1995) model outlines four phases: forethought, monitoring, control, and reflection, each encompassing cognitive, motivational, and behavioral components. These models provide frameworks for understanding how learners regulate their learning processes, particularly in digital environments.

Digital tools have become integral in facilitating SRL by providing scaffolds that support learners' metacognitive and strategic processes. Adaptive learning systems, intelligent tutoring systems, and learning analytics platforms offer real-time feedback, prompts, and personalized learning paths that aid in goal setting, self-monitoring, and strategy adjustment. For instance, the FLoRA engine (Li et al., 2024a) utilizes analytics to measure and facilitate learners' regulation activities, offering personalized scaffolding based on learners' interactions. Additionally, platforms like LEAP (Farrin et al., 2025) harness large language models to provide formative feedback, enhancing students' metacognitive skills and promoting self-regulation.

Empirical studies have consistently shown that SRL is a significant predictor of academic achievement and CI. A meta-analysis by Theobald (2021) found that SRL training programs positively impact students' academic performance, motivation, and use of regulation strategies. Furthermore, integrating SRL strategies into digital platforms has been linked to improved student achievement and performance. For example, a study by Elmabaredy and Gencel (2024) demonstrated that embedding SRL features into a Moodle platform enhanced students' academic outcomes and digital competencies.

Cognitive Engagement and Learning Autonomy

CE refers to the extent of mental effort and strategies that learners employ to comprehend complex concepts and acquire skills. It is often categorized into deep and surface engagement. Deep engagement involves critical thinking, making connections, and applying knowledge to new situations, whereas surface

engagement is characterized by rote memorization and minimal understanding. The interactive, constructive, active, passive (ICAP) framework further delineates CE into four modes, suggesting that interactive and constructive engagements lead to more significant learning outcomes than active or passive engagements (Culbreth & Martin, 2025).

The integration of digital tools in education has transformed how students engage cognitively. Studies indicate that digital educational games and interactive technologies can improve students' motivation and engagement, leading to improved learning outcomes. However, the quality of engagement is crucial; merely using digital tools does not guarantee deep CE. For instance, research has shown that while digital tools can facilitate engagement, they must be designed to promote meaningful interaction with content to be effective (Li et al., 2024b).

CE serves as a critical moderator in the relationship between DER and learning outcomes. High levels of engagement can amplify the positive effects of DER on learning, while low engagement may diminish these benefits. For example, a study found that students' CE levels significantly influenced their learning gains when using digital resources in programming education (Singh & Rajendran, 2024).

Recent research has employed moderate models to explore intricate relationships among technological use, psychological traits, and educational outcomes. For example, a study by Singh and Rajendran (2024) examined how CE moderates the relationship between DER and learning gains in programming education. Another study by Li et al. (2024a) investigated the moderating role of goal-setting behavior in the relationship between technological applications and digital learning behavior. These studies highlight the utility of moderation analysis in uncovering nuanced insights into educational phenomena (Zhang, 2021).

This study employed a moderation analysis to explore whether the relationship between students' use of DER and their CI varies depending on levels of MDL, SRS, and CE. Moderation analysis is appropriate when the goal is to test whether the strength or direction of an independent variable's effect on a dependent variable is contingent upon a third variable, known as the moderator (Hayes, 2017). In the context of this research, we hypothesized that the effectiveness of DER in promoting CI is not uniform across all learners but depends on their psychological dispositions and engagement behaviors. This approach aligns with contemporary perspectives in educational psychology and digital learning research, which emphasize the importance of individual differences in shaping technology-mediated learning outcomes (Memon et al., 2019).

METHODS

Participants

The participants in this study were undergraduate students enrolled in pedagogical specialties at Korkyt Ata Kyzylorda University, a multidisciplinary higher education institution located in Kyzylorda, Kazakhstan. As one of the region's oldest and most respected universities, Korkyt Ata Kyzylorda University has a strong tradition in teacher education, offering a wide range of programs supported by modern digital infrastructure and an active commitment to quality and innovation in teaching and learning.

A total of 276 students participated in the survey. In terms of age, 142 students (51.4%) were below 20 years old, while 117 students (42.4%) were between the ages of 20 and 25. The gender distribution was predominantly female, with 242 female participants (87.7%) and 34 male participants (12.3%). Participants were drawn from various grade levels: 47 were first-year students (17%), 100 were second-year (36.2%), 59 were third-year (21.4%), and 53 were fourth-year students (19.2%). Regarding their engagement with DER, 42 students (15.2%) reported using them for 0-2 hours per week, 128 students (46.4%) for 3-5 hours, and 73 students (26.4%) for 6-10 hours per week.

Instrument

The survey instrument used in this study was developed by the research team based on a thorough literature review and collaborative discussions focused on constructs central to digital learning and CI. The initial version included five dimensions: usage of digital educational resources (UDER), MDL, SRS, CE, and CI. After its initial development, two field experts in educational psychology and digital pedagogy reviewed the instrument for content validity. Based on their feedback, minor revisions were made to improve the precision

Table 1. Factor loadings

Items	Factor					Uniqueness
	1	2	3	4	5	
MDL1		0.80				0.22
MDL2		0.90				0.09
MDL3		0.74				0.21
MDL4		0.73				0.34
MDL5		0.93				0.16
MDL6		0.87				0.15
SRS1	0.77					0.19
SRS2	0.88					0.20
SRS3	0.88					0.12
SRS4	0.89					0.13
SRS5	0.90					0.11
SRS6	0.89					0.12
CE1				0.82		0.17
CE2				0.93		0.09
CE3				0.96		0.08
CE4				0.88		0.12
CE5				0.87		0.13
CI1					0.86	0.24
CI2					0.91	0.11
CI3					0.85	0.13
CI4					0.80	0.21
CI5					0.86	0.15
UDER1			0.67			0.35
UDER2			0.88			0.30
UDER3			0.80			0.26
UDER4			0.83			0.27
UDER5			0.92			0.11
UDER6			0.89			0.11

and relevance of item wording. To further ensure clarity and comprehensibility, three preservice teachers participated in a read-aloud session, resulting in additional refinements to improve the accessibility of language.

Each dimension was measured using multiple items rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). For example, the UDER dimension included items such as "I frequently use DER (e.g., online modules, e-books, educational apps) to support my learning." The MDL dimension featured items like "I enjoy using digital educational resources because they are engaging." The SRS dimension included statements such as "I set specific learning goals when using digital resources." The CE dimension captured items such as "I actively summarize key points from digital materials," and CI was assessed through items such as "I identify my learning needs without relying on instructors."

Internal consistency reliability was evaluated using Cronbach's alpha (α). The subscales demonstrated excellent reliability: UDER (α = .95), MDL (α = .96), SRS (α = .97), CE (α = .97), and CI (α = .96). The overall instrument reliability was α = .98, indicating a high degree of internal consistency across all items.

To establish the construct validity of the instrument, an exploratory factor analysis (EFA) (**Table 1**) was conducted using the *minimum residual* extraction method in combination with an *oblimin* rotation, which allows for correlation between factors. As shown in **Table 1**, the EFA supported a clear five-factor structure, aligned with the theoretical dimensions of the instrument. As indicated in **Table 1**, all items demonstrated strong loadings (> .67) on their respective factors. These results provide strong evidence of the construct validity of the instrument and confirm that each set of items measures a distinct, internally coherent latent variable as designed.

Figure 1 displays the results of a parallel analysis, comparing eigenvalues derived from the actual dataset (green dots) with those generated from simulated random data (orange dots). The plot illustrates that the first five eigenvalues from the actual data exceed those from the random simulations, indicating that five factors should be retained. This supports the five-factor structure identified in the EFA and aligns with the theoretical dimensions of the instrument.

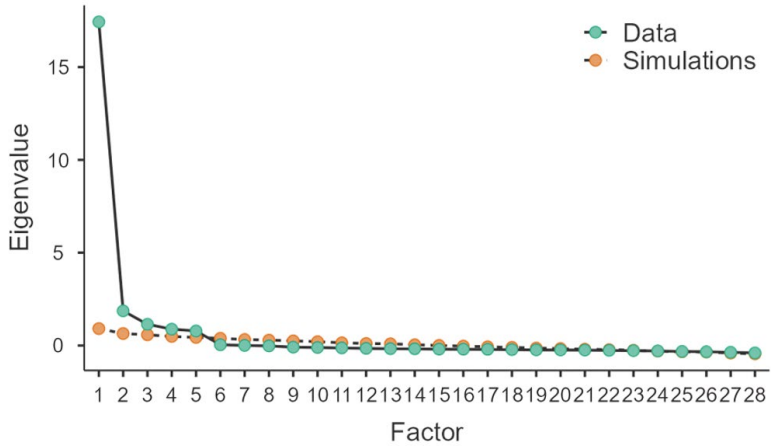

Figure 1. Parallel analysis scree plot for factor retention (Source: Authors)

Table 2. Moderation estimates: MDL

	Estimate	SE	Z	p
UDER	0.21	0.05	4.3	< .001
MDL	0.59	0.04	14.23	< .001
UDER ✻ MDL	-0.02	0.03	-0.58	0.563

Data Analyses

All data analyses were conducted using Jamovi 2.6.13 statistical software. To examine the construct validity of the instrument, an EFA was performed using the *minimum residual* extraction method with an *oblimin* rotation. The factor analysis confirmed a five-factor structure corresponding to the theoretical constructs presented in the survey. Factor loadings for all items exceeded .67, and uniqueness values were low, supporting the robustness of the latent constructs. To test the main hypotheses, General Linear Models were used to conduct moderation analyses, assessing whether the effect of digital resource usage on CI varied depending on levels of motivation, self-regulation, and engagement. Simple slope analyses were conducted for significant interactions to probe the nature of moderation effects at low (-1 standard deviation [SD]), average (mean), and high (+1 SD) levels of the moderator variables. Results were visualized using interaction plots to aid interpretation.

Ethical Statement

This study received ethical approval from the Scientific Ethics Committee of Korkyt Ata Kyzylorda University (approval date: February 27, 2025). The committee confirmed that the research procedures complied with institutional and national ethical standards. All participants were informed about the purpose of the study and participated voluntarily. Informed consent was obtained, anonymity was ensured, and no personal identifying information was collected. Participants were informed that they could withdraw at any time without penalty. No harm was caused to participants, and data were used solely for research purposes.

RESULTS

This section presents the findings from the moderation analyses conducted to explore the role of psychological variables in the relationship between the use of DER and students' CI. The results are presented sequentially by moderator variable, beginning with motivation, followed by SRS, and finally CE.

Table 2 presents the results of a moderation analysis conducted to examine whether MDL moderates the relationship between the UDER and CI. The moderation model includes three components: the main effect of digital resource usage, the main effect of motivation, and the interaction term representing the moderation effect. This analysis helps to determine whether the strength or direction of the relationship between digital resource use and CI varies based on the level of student motivation. As seen in **Table 2** first, the UDER is positively and significantly associated with CI (*estimate* = 0.21, *SE* = 0.05, *Z* = 4.3, *p* < .001), indicating that increased use of digital tools is linked to greater CI among students. Second, the MDL also displays a strong

Table 3. Simple slope estimates: MDL as moderator

	Estimate	SE	Z	p
Average	0.21	0.05	4.3	< .001
Low (-1 SD)	0.22	0.04	5.28	< .001
High (+1 SD)	0.19	0.07	2.91	0.004

Note. It shows the effect of the predictor (UDER) on the dependent variable (CI) at different levels of the moderator (MDL)

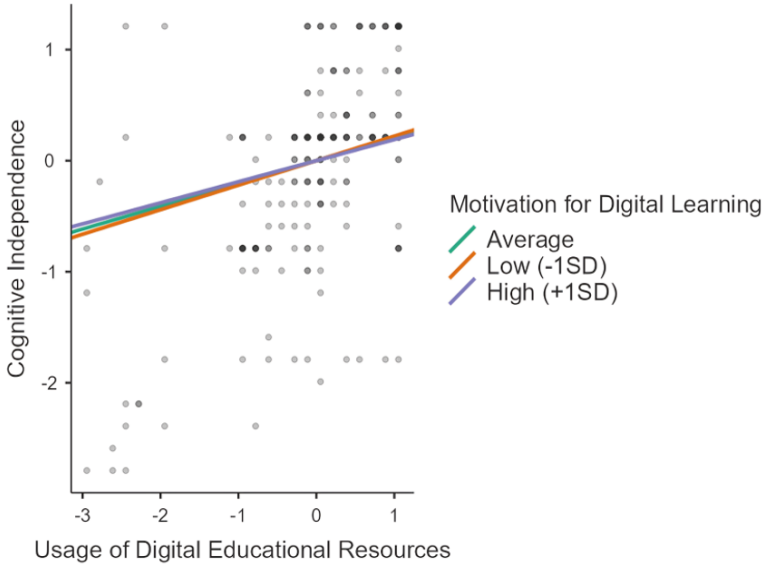

Figure 2. Simple slope plot of the moderation effect of MDL (Source: Authors)

and significant positive association with CI (*estimate* = 0.59, *SE* = 0.04, *Z* = 14.23, *p* < .001), showing that more motivated students tend to be more cognitively independent. Third, the interaction term (UDER ✻ MDL) is negative but not statistically significant (*estimate* = -0.02, *SE* = 0.03, *Z* = -0.58, *p* = 0.563), which indicates that motivation does not significantly moderate the relationship between digital resource use and CI. In other words, the effect of DER usage on CI remains consistent regardless of a student's level of motivation.

Table 3 provides the results of a simple slope analysis to further explore the nature of the interaction between UDER and MDL in predicting CI. Although the interaction term in the moderation model (see **Table 1**) was not statistically significant, simple slope analysis helps examine how the relationship between digital resource usage and CI behaves at different levels of motivation: low (-1 SD), average, and high (+1 SD).

Table 3 indicates that, first, at the average level of motivation, the usage of digital resources has a significant positive effect on CI (*estimate* = 0.21, *SE* = 0.05, *Z* = 4.3, *p* < .001). Second, at the low motivation level (−1 SD), the effect is slightly stronger (*estimate* = 0.22, *SE* = 0.04, *Z* = 5.28, *p* < .001), showing that students with lower motivation may benefit slightly more from using DER in terms of gaining CI. Third, at the high motivation level (+1 SD), the effect is still significant but somewhat weaker (*estimate* = 0.19, *SE* = 0.07, *Z* = 2.91, *p* = 0.004).

To sum up, although the differences across levels of motivation are minimal, these results indicate that the positive impact of digital resource usage on CI remains consistent and significant regardless of motivational level. The slight variation aligns with the non-significant interaction term in **Table 2**, reinforcing the conclusion that MDL does not meaningfully alter the strength of the relationship between digital resource usage and CI.

The findings in **Table 3** are visualized in **Figure 2**. It illustrates the interaction between UDER and MDL in predicting CI, based on simple slope analysis at three levels of motivation.

All three lines show a positive slope, indicating that greater use of DER is consistently associated with increased CI, regardless of motivation level. However, the slopes of the lines are nearly parallel and closely aligned, visually supporting the statistical finding from **Table 2** that the interaction effect is not significant (*p* = .563). This shows that motivation does not meaningfully moderate the relationship, in other words, the effect of digital resource usage remains stable across different motivational levels.

Table 4. Moderation estimates: SRS as moderator

	Estimate	SE	Z	p
UDER	0.28	0.05	6.07	< .001
SRS	0.48	0.04	12.04	< .001
UDER ⁕ SRS	-0.08	0.03	-2.44	0.015

Table 5. Simple slope estimates: SRS as moderator

	Estimate	SE	Z	p
Average	0.28	0.05	6.04	< .001
Low (-1 SD)	0.35	0.04	8.23	< .001
High (+1 SD)	0.21	0.06	3.28	0.001

Note. It shows the effect of the predictor (UDER) on the dependent variable (CI) at different levels of the moderator (SRS)

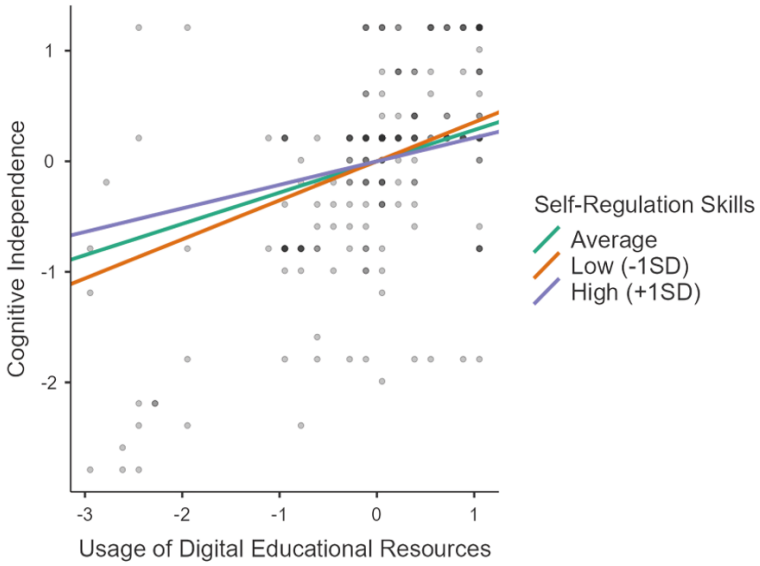

Figure 3. Simple slope plot of the moderation effect of SRS (Source: Authors)

Table 4 presents the moderation analysis examining whether SRS moderate the relationship between the UDER and CI. The model includes the main effects of digital resource usage and SRS, as well as their interaction term. This analysis aims to explore whether the strength of the relationship between using digital tools and developing CI varies depending on students' levels of self-regulation.

Table 4 shows that first, the main effect of UDER is positive and significant (*estimate* = 0.28, $p < .001$), indicating that students who use digital educational tools more frequently report higher levels of CI. Second, the main effect of SRS is also positive and highly significant (*estimate* = 0.48, $p < .001$), indicating that students with better self-regulation tend to be more cognitively independent. Third, the interaction term (UDER ⁕ SRS) is negative and statistically significant (*estimate* = -0.08, $p = 0.015$). This indicates a moderating effect: the positive relationship between digital resource usage and CI weakens as self-regulation increases.

Table 5 presents the simple slope analysis for the significant interaction between UDER and SRS in predicting CI. This analysis breaks down the effect of digital resource usage on CI at three distinct levels of the moderator, that is, self-regulation.

Several results are significant in **Table 5**. First, at average levels of self-regulation, the relationship between digital resource usage and CI is moderately positive and significant ($\beta = 0.28$, $p < .001$). Second, at low levels of self-regulation (-1 SD), the effect is strongest ($\beta = 0.35$, $p < .001$), indicating that students with weaker self-regulatory skills benefit more from using DER. Third, at high levels of self-regulation (+1 SD), the effect is weaker but still significant ($\beta = 0.21$, $p = .001$), showing that while digital tools still support independence, their marginal benefit diminishes for students who already self-regulate effectively.

Figure 3 visually represents the interaction between UDER and SRS in predicting CI. The plot includes three regression lines reflecting the relationship at low (-1 SD), average, and high (+1 SD) levels of self-regulation.

Table 6. Moderation estimates: CE as moderator

	Estimate	SE	Z	p
UDER	0.21	0.05	4.53	< .001
CE	0.54	0.04	13.92	< .001
UDER ✻ CE	-0.08	0.03	-2.6	0.009

Table 7. Simple slope estimates: CE as moderator

	Estimate	SE	Z	p
Average	0.21	0.05	4.51	< .001
Low (-1 SD)	0.28	0.04	6.74	< .001
High (+1 SD)	0.13	0.06	2.11	0.035

Note. It shows the effect of the predictor (UDER) on the dependent variable (CI) at different levels of the moderator (CE)

All three lines in **Figure 3** demonstrate a positive relationship between digital resource usage and CI, indicating that as students use DER more, their CI increases across all levels of self-regulation. However, the steepness of the slope varies, which visually supports the significant interaction term reported in the moderation estimates (p = .015). First, the orange line (low self-regulation) is the steepest, displaying that students with lower self-regulation benefit the most from increased use of DER. Second, the green line (average self-regulation) shows a moderate effect. Third, the purple line (high self-regulation) is the least steep, indicating that for students who already regulate their learning effectively, additional digital resource use offers less added benefit to their CI.

Table 6 reports the moderation analysis examining whether CE moderates the relationship between UDER and CI. This analysis evaluates whether the effect of digital resource usage on students' independence varies according to their level of CE in learning activities.

There are three main findings in **Table 6**. First, the main effect of UDER is positive and significant (*estimate* = 0.21, p < .001), indicating that greater use of digital tools is associated with increased CI. Second, the main effect of CE is also strong and significant (e*stimate* = 0.54, p < .001), meaning students who are more cognitively engaged tend to be more independent learners. Third, importantly, the interaction term between digital resource usage and CE is negative and statistically significant (*estimate* = -0.08, p = .009). This displays that CE moderates the relationship that as engagement increases, the positive effect of digital resource usage on CI diminishes.

Table 7 presents the simple slope analysis that explores the nature of the significant interaction between UDER and CE in predicting CI. This analysis breaks down the effect of the UDER usage on independence at three levels of CE.

As seen in **Table 7**, first, at the average level of CE, the UDER has a moderately positive and statistically significant effect on CI (β = 0.21). Second, at the low engagement level, the effect is stronger (β = 0.28), presenting that students who are less engaged cognitively benefit more from digital resources in developing independent learning skills. Third, at the high engagement level, the effect is weaker but still significant (β = 0.13), indicating that digital tools still contribute to CI but to a lesser extent for highly engaged students.

Figure 4 visualizes the moderating role of CE in the relationship between UDER and CI. It shows three regression lines representing the effect of digital resource usage at different levels of CE.

The key observation in **Figure 4** is that all three lines have positive slopes, confirming that greater use of DER is associated with higher CI, regardless of engagement level. However, the steepness of the slopes varies, reflecting the statistically significant interaction effect reported in **Table 6** (p = .009):

DISCUSSION

This study investigated how the use of DER influences students' CI and whether this relationship is moderated by psychological variables including MDL, SRS, and CE. The findings revealed several important patterns. First, DER usage was found to be a significant and positive predictor of CI, showing that students who more frequently engage with digital learning tools tend to exhibit greater autonomy in their learning processes. Second, MDL, SRS, and CE each demonstrated strong, direct positive effects on CI.

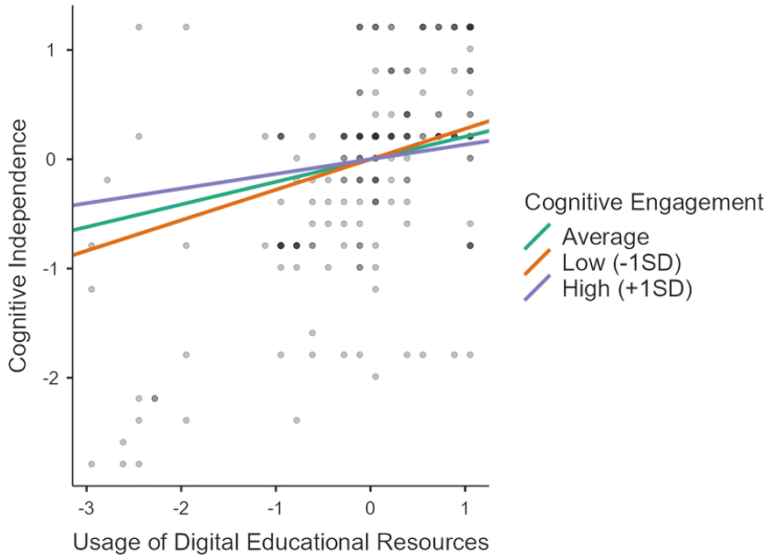

Figure 4. Simple slope plot of the moderation effect of CE (Source: Authors)

However, only SRS and CE moderate the relationship between DER usage and CI. Specifically, the positive effect of DER on independence was stronger among students with lower levels of self-regulation or engagement. This indicates that students who are less psychologically prepared may benefit more from DER in developing independent learning competencies. In contrast, motivation did not significantly moderate this relationship, indicating that the benefits of DER for CI are relatively stable across varying levels of student motivation.

This study includes meaningful findings about how DER supports the development of CI and how this effect is influenced by psychological variables. Consistent with SDT, the positive relationship between DER usage and CI aligns with the idea that environments promoting autonomy, such as flexible, student-centered digital platforms, can improve more self-directed learning behaviors. However, contrary to what SDT might suggest, MDL did not moderate the relationship between DER and CI. This implies that DER can be equally beneficial across students with varying levels of intrinsic motivation, possibly because the design features of DER (e.g., interactivity, personalization) provide external scaffolding that partially compensates for motivational differences.

In line with SRL Theory, self-regulation emerged as both a strong predictor and a moderator. The finding that students with lower SRS benefit more from DER suggests that digital platforms may serve as external support that help structure the learning process for students lacking internal regulation mechanisms. This supports the view that digital tools, through features like goal-setting prompts, feedback systems, and learning analytics, can guide students toward greater independence, particularly when their self-regulatory skills are underdeveloped (Onah et al., 2021). Similarly, CE was both a significant predictor and a moderator. Students with higher engagement levels were more likely to be cognitively independent, but interestingly, those with lower engagement showed greater gains in independence from DER usage. This suggests a compensatory effect, where DER may stimulate deeper cognitive involvement among less engaged students by offering more interactive and engaging learning experiences. This aligns with the EVT, which posits that task value and perceived utility drive effort and persistence (Nagle, 2021), DER likely boosts these perceptions, especially for students who initially lack strong CE.

The results of this study affirm and expand upon several strands of existing research. First, the positive association between DER usage and CI supports earlier findings that digital learning environments can improve autonomous learning behaviors by providing flexibility, immediate feedback, and personalized content (Ifenthaler & Yau, 2020; Lee et al., 2014). This aligns with SDT, which suggests that environments promoting learner autonomy enhance self-regulation and motivation (Guay, 2022). Prior studies have similarly found that digital tools increase learners' perceived autonomy and self-directed engagement (Jeno et al., 2017).

However, this study diverges from some prior findings in regard to motivation as a moderating variable. Although motivation was a strong direct predictor of CI, as expected from SDT and EVT (Eccles & Wigfield, 2002), it did not significantly moderate the relationship between DER usage and CI. This differs from studies such as Bi et al. (2024) and Gm et al. (2024), which identified motivation as a significant moderator in digital learning contexts. A possible explanation may lie in the universality of DER benefits in this context; even less motivated students may gain from DER due to its structural features that scaffold independence regardless of initial motivational levels.

In contrast, SRS significantly moderate the DER, independence link, with stronger effects for students with lower self-regulation. This finding is consistent with SRL theory (Pintrich, 1995; Zimmerman, 2002) and extends prior empirical work (Elmabaredy & Gencel, 2024; Theobald, 2021), which has shown that digital platforms enhance learning outcomes by supporting students' regulatory processes. Our findings stresses DER's potential to compensate for low internal regulation by providing structured guidance and feedback mechanisms.

Similarly, CE moderated the effect of DER on independence, supporting findings from Singh and Rajendran (2024) and Singh and Rajendran (2024), who reported that students with lower engagement levels can experience amplified benefits from well-designed digital resources. This moderation also reflects the ICAP framework (Culbreth & Martin, 2025), which says that digital environments must encourage constructive and interactive engagement to maximize learning outcomes. Students who were less engaged may have found DER more novel or stimulating, thereby increasing their cognitive involvement and independence.

This study makes several important contributions to the research on digital education and learner autonomy. First, it offers empirical evidence that DER significantly promote CI, reinforcing the role of DER as tools for content delivery, and as catalysts for developing autonomous learning behaviors. While previous studies have emphasized DER's influence on academic performance, engagement, or satisfaction (Wang et al., 2023; Wong et al., 2025), fewer have directly examined their effect on students' ability to self-direct, self-monitor, and take responsibility for their own learning. This study helps to fill that gap by focusing on CI as a distinct and essential outcome in digital learning environments.

Second, the study adds depth to the literature on SRL by showing that students with lower SRS or engagement derive greater benefits from DER usage. This suggests that digital tools may act as scaffolds, especially for students who have not yet developed strong internal regulatory strategies. While prior research has shown that high self-regulation predicts academic success (Elmabaredy & Gencel, 2024; Theobald, 2021), this study reveals that DER can play a compensatory role, thereby promoting equity by helping less-prepared learners develop the independence needed for academic success.

In terms of implications, the positive relationship between DER usage and CI indicates the value of integrating DER as a central component of instructional practice, not merely as supplemental tools. Moreover, educators should consider differentiating instructional strategies by incorporating DER more deliberately for learners who display lower levels of autonomy. Furthermore, in teacher training programs, emphasis should be placed on developing digital pedagogical competencies, including how to select and implement DER that support content mastery and also the development of CI.

In terms of future research, first, future studies should explore the specific features or types of DER that are most effective in promoting CI. Investigating which design elements, such as gamification, real-time feedback, adaptive pathways, or collaborative components, are most influential can provide actionable results for instructional designers and educational technologists. Second, future investigations should examine broader or more diverse populations. This study was conducted with undergraduate students from a single university in Kazakhstan, which may limit the generalizability of the findings. Third, given that motivation did not significantly moderate the relationship between DER and CI in this study, future research might explore other psychological or contextual moderators, such as digital literacy, socioeconomic status, prior technology experience, or teacher support.

In terms of limitations, first, the research design was cross-sectional and correlational, which restricts the ability to make causal claims. Second, the sample was drawn from a single university in Kazakhstan, limiting the generalizability of the findings. Third, the number of male and female participants very different. Finally, the specific types and quality of DER used by participants were not examined in detail.

CONCLUSION

This study explored the relationship between the use of DER and the development of CI among university students, while also examining the moderating roles of MDL, SRS, and CE. The findings confirmed that DER usage is a significant and consistent predictor of CI, highlighting the potential of digital tools to foster autonomous learning behaviors. Moreover, while motivation and engagement were strong direct predictors of independence, only SRS and CE significantly moderated the DER–independence relationship. These moderation effects revealed that students with lower self-regulation or engagement benefited more from DER, underscoring the compensatory value of digital tools in supporting less-prepared learners.

The study contributes to the literature by focusing on CI as a distinct outcome of digital learning and by identifying for whom DER is most effective. It emphasizes the importance of tailoring digital pedagogies to individual learner profiles, particularly in supporting those who may lack the psychological readiness for self-directed learning. The results also call for more strategic and inclusive integration of DER in higher education, aimed not only at delivering content but also at cultivating 21st century competencies such as autonomy, self-regulation, and lifelong learning. As educational environments continue to evolve, these findings show the importance of using digital resources thoughtfully to empower all students, especially those who need them most.

Author contributions: GU: conceptualization, methodology, project administration, writing – original draft; **GI:** data collection, resources, validation, writing – review & editing; **RU:** formal analysis, data curation, visualization; **GK:** conceptualization, formal analysis; **MM:** writing – original draft, writing – review & editing. All authors approved the final version of the article.

Funding: The authors received no financial support for the research and/or authorship of this article.

Acknowledgments: The authors would like to thank the participants and colleagues who supported this study.

Ethics declaration: This study was approved by the Scientific Ethics Committee at Korkyt Ata Kyzylorda University on 27 February 2025). All participants provided informed consent prior to participation and were informed that their involvement was voluntary and that they could withdraw at any time without consequence. Personal and sensitive data were anonymized, securely stored, and used solely for research purposes in accordance with institutional ethical guidelines.

Declaration of interest: The authors declared no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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