The Impact of Digital Technologies on the Students' Independent Learning Development

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***Abstract*—This study examines the impact of digital technologies on students' learning independence. Data was collected from 450 students and 50 educators within EU universities sing a structured Learning Independence Questionnaire focused on self-regulation, time management, problem-solving, adaptability, and the perceived impact of technology. Multiple regression analysis identified significant predictors of learning autonomy, and Cohen's d quantified differences in perception between students and educators. Results indicate that students observe greater benefits from digital technologies than educators, particularly in self-regulation, problem-solving, and the perceived impact of technology (Cohen's d = 0.23–0.31). This suggests a potential undervaluation of digital learning benefits by educators or an overestimation by students. Self-regulation is the strongest predictor of learning independence (β = 0.35, p < 0.001). Analysis also revealed that STEM students reported higher levels of learning independence than humanities students (p = 0.03), and postgraduate students reported higher levels than undergraduates (p = 0.02). Limitations include the reliance on self-reported data, the sample's focus on EU universities, and the questionnaire's focus on five key indicators. Findings suggest a need for tailored educational strategies that leverage digital tools to enhance learning autonomy. To achieve this, educators could consider aligning their approaches with students' perceived benefits by providing structured support and integrating digital tools to foster self-regulation, problem-solving, and adaptability, thereby bridging the perception gap and optimizing digital learning environments for diverse educational backgrounds.**

***Keywords*—autonomy, independence, learning, digital technologies, education, competence**

I. Introduction

The rapid evolution of digital technologies has transformed educational environments, broadening access to resources and enabling students to actively shape their learning experiences. Digital platforms, mobile apps, and collaborative software empower students to take control of their learning processes, supporting flexible environments that accommodate various learning styles. These tools allow students to learn at their own pace, set personal goals, and track their progress, which has sparked interest among educators and researchers in examining how digital technologies contribute to or hinder the development of student autonomy. The 2023 Global Education Monitoring Report [1] illustrates the growing role of digital proficiency, noting that between 2015 and 2021, tertiary education enrollment increased globally, and digital skills improved across several high-income countries, underscoring the importance of technology-enabled autonomy in educational settings. The use of digital tools in higher education has been widely studied, with research showing their effectiveness in fostering independent learning and self-regulation [2]. Timotheou *et al*. [3] emphasize that while digital technologies improve educational experiences, their effectiveness depends on institutional readiness, digital competence, and pedagogical integration. Pratiwi and Waluyo [4] further highlight that digital learning environments can promote student autonomy, particularly when well-structured guidance is provided. These findings demonstrate the evolving role of digital technologies in shaping modern education, underscoring the need to analyze their impact on learner independence from both student and educator perspectives.

Autonomy in learning is increasingly recognized as a critical component of academic success, enhancing self-directed learning, motivation, and adaptability [5]. Studies show that autonomy encourages students to develop independent learning strategies and fosters resilience, which are crucial for long-term success [6]. However, while digital technologies can enhance autonomy, they also pose potential drawbacks, such as reduced self-regulation and time management due to increased reliance on digital tools. Research suggests that although digital technologies provide benefits, they can also introduce challenges like distraction and procrastination, highlighting the need for a nuanced understanding of their influence on different aspects of learning autonomy [7, 8].

Furthermore, while extensive research explores student perspectives on digital tools [2, 4, 9–12], a significant gap persists in understanding educators' views on their impact on learning independence. Studies exploring student perspectives often highlight increased access to information and personalized learning [2, 9–10], but less frequently address the nuanced challenges educators face in fostering independence within technology-rich environments. This disparity underscores the need for a comprehensive examination of both student and educator viewpoints to fully comprehend the role of digital technology in promoting independent learning.

Grounded in the Self-Determination Theory (SDT) [2, 3], which emphasizes the importance of autonomy, competence, and relatedness in fostering motivation and learning, this research seeks to provide a robust theoretical framework for understanding the dynamics of digital learning environments. SDT posits that autonomy support from educators is crucial

for students to develop independent learning skills [13]. By examining how educators perceive their role in fostering autonomy through technology, this study provides insights into the practical application of SDT principles in digital learning contexts.

This research extends beyond the predominantly EU-centric focus of existing literature by incorporating perspectives from diverse educational systems, including those in developing countries [14–19]. This broader scope allows for a more nuanced understanding of the global relevance of digital technology in education and its adaptability across varying cultural and economic contexts. The study contributes to the field by offering a comparative analysis that not only highlights the divergence in student and educator views but also explores the applicability of its findings in diverse educational settings. This approach seeks to provide a more holistic understanding of the role of digital technology in enhancing the learning experience [3, 20–22], ultimately informing the development of more effective and equitable digital learning strategies.

This research addresses these gaps and investigates the impact of digital technologies on students' learning autonomy by examining both student and educator perspectives across European Union universities. It focuses on five key dimensions: self-regulation, time management, problem-solving, adaptability, and the perceived impact of digitalization. Through multiple regression and effect size analysis (Cohen's d), the research seeks to quantify perceptual differences, identify the most influential factors contributing to learning independence, and assess variations based on academic field and education level. The findings provide insights into how digital tools can be optimized to enhance independent learning and bridge perception gaps between students and educators.

II. Literature Review

Modern educational approaches are undergoing significant changes. The fundamental goal of the educational process is to train a competent future specialist whose professionalism will successfully combine specialized, narrowly focused knowledge and skills, as well as aspects such as autonomy, time management, perception of modern digitalization, etc. The work by Zhuzeyev *et al*. [14] emphases that the formation of future competence as a self-sufficient characteristic is based on ethnopsychological features and ethnopedagogical traditions. Considering this process as a holistic model, the authors mention that the traditional elements of future competence formation are the simultaneous development of cognitive, communicative and ethnocultural aspects. The achievement of high results in students' learning can be interpreted as a consequence of the successful application of modern technologies and methodological support for the use of ethnocultural materials in professional training.

The transition to self-directed learning, where individuals take initiative and responsibility for their learning, has been significantly facilitated by distance education, a form of learning that leverages computer and Internet technologies. This environment often requires and fosters independent learning, where students develop the ability to learn autonomously and manage their own learning process, including self-regulation (monitoring and controlling one's own learning) and taking responsibility for outcomes. Guldaray and Karlygash [15] concluded that distance learning provides a valuable platform for developing professionally and information-relevant competencies, fostering personal growth, promoting systemic thinking, and enhancing students' ability to work independently.

Moore [23] proposed a foundational Theory of Independent Learning, which distinguishes between learner autonomy and the degree of separation between teacher and learner. According to Moore's theory, the greater the transactional distance (the psychological and communicative gap) between teacher and student in a learning environment, the more learner autonomy is required for successful learning. This is particularly relevant in distance and digital learning environments, where students often have more control over their learning process and pace. This framework encourages students to personalize their learning experience by setting their own goals and controlling their pace, elements that are essential in digital learning environments. Furthering this, Moore [24] examined the development of distance learning theories, underscoring the role of high learner autonomy in fostering a preference for non-traditional learning modes. While Moore's early work laid the groundwork for understanding independent learning in distance education, the proliferation of diverse digital tools and the nuances of student and educator perceptions in these contemporary environments warrant further investigation, which this study aims to address. This shift reflects broader changes in educational content delivery, especially as digital tools become more prevalent. Building on this foundation, Suphandee *et al*. [16] identified four primary components of students' learning autonomy: learning strategies, problem-solving skills, self-efficacy, and a love of learning. These indicators highlight that autonomous learners not only develop specific skills but also cultivate self-awareness and motivation, aligning with educational goals emphasizing lifelong learning and independent problem-solving abilities.

To be independent in learning means that students exhibit self- and situation-understanding, as well as self-regulation [17]. For teachers, independence translates to the freedom to design, develop, and implement curriculum tailored to the students' potential and needs. This concept of independent learning also emphasizes supporting students' rights to a balanced learning period and load, enhancing autonomy by allowing educators to adapt teaching methods to better meet diverse learning needs [18]. The independent learning policy further redefines education by fostering an innovative and creative culture in higher education, where educators can freely apply multiple disciplines to address students' evolving needs [19].

Significant evidence shows that support for human autonomy promotes better engagement, performance, and well-being across domains such as business, education, and health care [5, 25]. This aligns with Self-Determination Theory, which posits that individuals have innate psychological needs for autonomy, competence, and relatedness, and that satisfying these needs fosters intrinsic motivation and well-being [5]. In educational settings, supporting students' autonomy, as emphasized by SDT, can lead to greater engagement and internalization of learning [6],

and autonomy-supportive teaching contributes benefits to both students and teachers [13].

Learner autonomy, self-learning management, and independent learning are interconnected concepts focusing on learners developing skills for learning outside the classroom or without constant instruction [2, 26]. The discussion of independent learning frequently arises in the context of student-teacher roles and relationships, and the role of information and communications technology in learning [3, 20].

Pramesworo *et al*. [9] further emphasize that blended learning environments support the development of independent learning skills when combined with teacher support and access to technological resources, promoting a balanced integration of digital and traditional teaching methods. Similarly, Li [27] underscores that cultivating self-directed skills like self-management, decision-making, and self-assessment builds independence, ultimately contributing to lifelong learning capabilities. This aligns with educational objectives favoring autonomy beyond the classroom, preparing students to thrive in diverse learning environments.

Learner autonomy is often linked to maturity, self-motivation, and flexible learning, as noted by Koban Koç and Koç [28], who explored its cognitive, metacognitive, and social dimensions in a computer-based classroom. Students are autonomous through their perceptions relevant to learner autonomy (i.e., responsibilities, decision-making abilities, the use of metacognitive strategies), motivation, and autonomous learning activities [29]. Getie [30] further describes autonomy as students' ability to manage their learning pace and content ownership. In studies on English language learning, Agustina [31] and Ahsanu [32] observed that autonomy positively impacted student performance. These findings align with Benson and Voller's [33] hypothesis that autonomy is a student's inherent potential, which educators can foster through relevant curricula. Kul [21] discusses how technological advancements have significantly fostered autonomous language learning by supporting personalized learning pathways, goal-setting, and self-monitoring. The use of digital tools enables learners to control their progress and adapt their strategies, thereby enhancing autonomy. This integration not only facilitates independence in learning but also aligns with educational trends favoring student-centered approaches [22]. Concurrently, not all students benefit equally from digital learning autonomy. Scheel *et al*. [34] emphasize that self-organization and digital competence are prerequisites for digital learning effectiveness. Students from institutions with weaker digital infrastructures or lower digital literacy skills may struggle to fully leverage these tools, exacerbating educational inequalities.

Specific digital tools tailored to content areas can enhance independence even further. Suci and Reflina [22] demonstrated that digital applications like GeoGebra support independence in learning mathematics, highlighting the benefit of subject-specific tools in strengthening students' abilities to manage their learning. Likewise, Matamay *et al*. [35] found that discovery learning enhances academic outcomes and autonomy, suggesting that inquiry-based approaches in digital learning environments support students in taking active roles in their learning process.

For the purpose of this study, "digital technologies" encompass a range of tools and platforms that utilize computers and the internet to facilitate learning, including but not limited to distance learning platforms, blended learning environments, educational software, and online resources. Distance learning is a specific mode of education that primarily relies on digital technologies to connect teachers and students remotely. Blended learning represents an integration of traditional face-to-face instruction with digital learning technologies. This study examines the impact of digital technologies in a broad sense, encompassing both fully online and blended learning contexts, on students' learning autonomy.

Digital competencies and self-organization are crucial for students to fully benefit from digital learning. Scheel *et al*. [34] argue that students' acceptance of digital learning is influenced by these competencies, suggesting that educators should support students in enhancing their self-organization to foster independent study habits. This is echoed by Pan *et al*. [10], who found that students' independent learning abilities are significantly influenced by their intention to use intelligent learning tools, with information quality and satisfaction as pivotal factors in enhancing autonomy. The quality of digital tools, therefore, becomes essential for effective autonomous learning.

Pratiwi and Waluyo [4] argue that digital tools can effectively support self-reliance, linguistic confidence, and the development of learning strategies, particularly in online settings. Their study highlights the shift from teacher-centered to student-centered learning, underscoring the potential of technology to enhance autonomous learning outcomes.

The OECD's PISA 2025 framework [36] emphasizes the need for digital literacy skills as a core component of education. It highlights that digital environments offer unique opportunities to foster autonomous learning by enabling students to engage in problem-solving, critical thinking, and creative tasks in diverse, technology-driven settings. This aligns with broader educational trends that prioritize adaptability and self-directed learning in the digital age [17, 18].

While studies like [10–12, 22, 34, 35] highlight the benefits of digital tools, they also present significant challenges. Dontre [8] reminds us of the potential limitations and explores how technology influences academic distraction, suggesting that while digital tools enhance learning autonomy, they also present significant challenges. He emphasizes the dual impact of technology: on one hand, it supports independent learning and access to resources, but on the other, it can lead to distractions that hinder focus and productivity. These findings reflect the complex role that digital technologies play in shaping modern learning environments.

Researchers employ various indicators to assess independence, including self-awareness and self-regulation [37], critical thinking [38], problem-solving and time management [39], self-organization [34] and responsibility [40]. Paul [41] also emphasizes that independent learners often show increased confidence, discipline, and persistence, qualities essential for navigating digital learning environments [2]. Martin *et al*. [42] argues that adaptability is essential for students to effectively harness digital technologies for independent learning, enhancing their ability

to navigate new tools and varied learning environments confidently. The development of independent learning through digital learning environments also cultivates essential soft skills such as self-management, critical thinking, and problem-solving, which are highly valued in today's professional landscape. Although digital learning environments promote independence, educators still play a critical role in scaffolding digital autonomy. Pratiwi & Waluyo [4] found that students require structured support to develop independent learning habits. Simply providing digital tools does not automatically lead to self-regulated learning – teacher guidance remains essential.

To establish a strong conceptual foundation, this study integrates Self-Determination Theory and Moore's Theory of Independent Learning as guiding frameworks. These theories inform this study's conceptual model, which posits that students' engagement with digital technologies influences their levels of self-regulation, time management, problem-solving skills, and adaptability.

In conclusion, while extensive research has explored the role of digital tools in fostering learner autonomy, a gap remains in understanding the nuanced differences between student and educator perspectives on how digital learning influences independence, adaptability, and time management. This study seeks to bridge this gap by offering a comparative analysis of both groups' perspectives, ensuring a more comprehensive understanding of how digital tools influence learning independence. Although this study primarily focuses on five key variables within digital learning environments, the development of self-regulation and adaptability may also have indirect effects on students' cognitive and communicative skills in digital settings. However, the ethnocultural aspects of learning—identified by Zhuzeyev *et al*. [14] as fundamental to traditional competence formation – may require a distinct and in-depth investigation in relation to digital education, which falls outside the immediate scope of this study.

This study aims to examine the impact of digital technologies on students' independent learning by analyzing student and educator perspectives, focusing on self-regulation, time management, problem-solving, adaptability, and the perceived impact of digitalization. This research seeks to explore these aspects by testing hypotheses:

Hypothesis 1: Students perceive that digital technologies significantly enhance their learning independence across multiple domains, including self-regulation, time management, problem-solving, and adaptability.

Hypothesis 2: Students rate their time management and organization skills higher than educators rate those skills for students in the context of digital learning environments.

Hypothesis 3: Students' perceptions of digital technologies' impact on learning independence vary, influenced by their field of study and education level.

III. Methodology

A. Learning Independence Questionnaire

This study employs a quantitative approach using surveys to analyze how digital technologies influence student learning independence. The Learning Independence Questionnaire was refined through a process of theoretical and empirical validation, similar to Sa'adah and Ikhsan's [43] approach, which involved both expert reviews and empirical testing. For our study, pre-testing was conducted among focus groups from four universities: Saken Seifullin Kazakh Agrotechnical University, Korkyt Ata Kyzylorda University, Karaganda Buketov University, and Abay Myrzakhmetov Kokshetau University. This stage ensured content relevance and clarity before broader deployment. Each item was analyzed for validity and reliability, with unidimensionality tested to confirm that the questionnaire effectively measures the targeted aspects of learning independence.

To ensure the validity and reliability of the LIQ, we adopted the approach used by Sa'adah and Ikhsan [43], which emphasizes systematic validation through expert review and empirical testing. This method involves three key stages:

- Expert Validation—The questionnaire was reviewed by five specialists in educational psychology and digital learning to assess content validity and conceptual clarity. Items were refined based on expert feedback.
- Pilot Testing—A pre-test was conducted with 50 students and 10 educators across four universities to ensure clarity and relevance. Participants provided feedback on wording and usability.
- Reliability Testing—The final version of the questionnaire was analyzed using Cronbach's alpha ($\alpha = 0.89$), indicating high internal consistency and confirming that the instrument effectively measured learning independence.
- Unidimensionality Analysis—A factor analysis (KMO = 0.82, Bartlett's test $p < 0.001$) confirmed that the questionnaire items measured a single underlying construct of learning independence, as required for valid interpretation.

This rigorous validation ensures that LIQ provides reliable insights into student and educator perceptions of digital technologies' impact on learning independence. During the expert validation phase, specialists provided valuable feedback. For instance, one expert suggested rewording items for clarity in cross-cultural settings, while another emphasized the inclusion of negatively worded statements to reduce response bias. Another validator recommended aligning the "Adaptability" scale more closely with students' digital fluency, leading to the refinement of specific indicators. These comments played a key role in strengthening the construct validity of the instrument.

The Learning Independence Questionnaire (LIQ) includes five sections to comprehensively assess how digital technologies impact students' learning independence (see Appendix A and Table 1). The questionnaire items were developed based on an extensive review of the literature on digital learning and autonomy, ensuring alignment with established theories such as Moore's [23, 24] Theory of Independent Learning and Self-Determination Theory [5]:

- Self-Regulation and Autonomy: Measures students' ability to manage their own learning. This is crucial as digital tools can both support and challenge self-directed learning [25, 29, 31, 33, 35, 37].
- Time Management and Organization: Evaluates how well students organize their time in flexible digital environments, where distractions can be more prevalent [27, 34, 39].
- Problem-Solving and Critical Thinking: Assesses students'

ability to tackle challenges and think critically. Digital tools offer vast information, making these skills essential for independent learning [2, 16, 36, 39].

- Adaptability to Digital Learning: Gauges students' flexibility in adjusting to new digital tools and platforms, a key skill as digital learning evolves rapidly [10–12, 42].
- Perceived Impact of Digital Technologies: Captures students' views on whether digital tools enhance or limit their learning independence, providing balanced insights into their experiences [3, 10, 20, 37, 39].

Table 1. Learning independence questionnaire grid

No.	Indicator	Positive Statements	Negative Statements	Total
1	Self-Regulation and Autonomy	1, 2, 3, 4, 5	6	6
2	Time Management and Organization	7, 8, 9	10	4
3	Problem-Solving and Critical Thinking	11, 12, 13	14	4
4	Adaptability to Digital Learning	15, 16, 17	18	4
5	Perceived Impact of Digital Technologies	19, 20, 21	22	4
Total		15	7	22

These sections provide a balanced view of essential skills, offering a comprehensive analysis of learning independence in digital contexts. LIQ was administered to students and educators, featuring statements covering multiple aspects of learning independence.

For educators, all items of the student surveys were rephrased into items related to educators' perceptions of their students' attitudes and experiences. Using the same questionnaire from the educators' viewpoint helps us understand how both groups perceive digital tools' impact, revealing potential gaps between expectations and experiences. Griffioen [44] highlights that even though educators and students are not evaluating the same individuals, comparisons between their perceptions of research integration can yield valuable insights. The comparison of research attitudes, experiences, and context between lecturers and students provides essential data that reflects the gaps in perceptions and opportunities for alignment in educational practices.

By incorporating negative statements alongside positive ones, the questionnaire offers a more nuanced analysis of how students and educators perceive learning independence in the context of digitalization tools. This approach reduces the risk of positive bias and allows the study to explore any perceived limitations or challenges associated with digital learning environments.

B. Sample and Participant Selection

The study involved a total of 450 students and 50 educators from a variety of universities across the EU. This study focused on universities in the European Union due to their advanced integration of digital learning tools and established policies on autonomous learning. These institutions provide an ideal context for analyzing the relationship between digital education and learning independence. However, future research should explore developing regions to assess the transferability of these findings.

The electronic survey was distributed through institutional channels, with anonymous responses to encourage honest feedback. Stratified random sampling was employed to ensure diverse representation based on gender, academic level, field of expertise, and familiarity with digital learning technologies:

- Students: Representing different levels (undergraduate, graduate, postgraduate), various fields of study, and differing levels of exposure to digital learning (from occasional to frequent users).
- Educators: University faculty members and teaching assistants experienced in delivering digital or online courses, who have supervised or engaged with students in digital learning environments.

A background survey gathered information on participants' demographics and learning contexts, including:

- Gender (Male, Female, Other)
- Level of Education (Undergraduate, Graduate, Postgraduate)
- Study Period (1-2 years, 3-4 years, 5+ years)
- Field of Expertise (STEM, Social Sciences, Humanities, Other)
- E-learning Intensity (The measurement of e-learning intensity means the duration of engagement with the online learning platform per week: 1-2 times, 3-4 times, 5+ times)

The participants' breakdown is summarized in Table 2.

Table 2. Survey participants' breakdown

Demographic Variable	Category	Number of Students (n = 450)	Number of Educators (n =5 0)
Gender	Male	218	23
	Female	228	27
	Other	4	-
Level of Education	Undergraduate	223	-
	Graduate	142	5
	Postgraduate	85	45
Field of Expertise	STEM	142	18
	Social Sciences	128	15
	Humanities	101	12
	Other	79	5
Study Period	1–2 years	179	N/A
	3–4 years	180	N/A
	5+ years	91	N/A
Work Experience	1–2 years	N/A	7
	3–4 years	N/A	15
	5+ years	N/A	28
E-learning Intensity	1–2 times per week	100	17
	3–4 times per week	192	16
	5+ times per week	158	17

Participants rated their agreement with each item on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Quantitative data from the Learning Independence Questionnaire were analyzed using descriptive statistics (mean, mode, and standard deviation) to provide an overview of responses.

To ensure ethical compliance, all participants were required to sign an informed consent form before completing the questionnaire. Participation was voluntary, and respondents were informed that they could withdraw at any time without consequence. Anonymity was maintained, and no personally identifiable information was collected. Participants were also briefed on the study's goals, potential benefits, and the absence of foreseeable risks.

C. Data Analysis

Multiple regression analysis was applied to examine how factors like self-regulation, time management, problem-solving, adaptability, and perceived impact influence students' learning independence. For this analysis, SPSS (Statistical Package for the Social Sciences) was utilized, allowing for robust data manipulation and detailed statistical analysis.

To gain deeper insights into the factors that significantly impact students' perceptions of learning independence, a multiple regression model was constructed:

- Dependent Variable: Learning Independence (composite score from the Learning Independence Questionnaire)
- Independent Variables:

1) Self-Regulation and Autonomy
2) Time Management and Organization
3) Problem-Solving and Critical Thinking
4) Adaptability to Digital Learning
5) Perceived Impact of Digital Technologies

The regression model is specified as follows:

$$Y_{Learning\ Independence} = \beta_0 + \beta_{1(Self-Regulation)} + \beta_{2(Time\ Management)} + \beta_{3(Problem-Solving)} + \beta_{4(Adaptability)} + \beta_{5(Perceived\ Impact)} + \epsilon \quad (1)$$

where: $Y_{Learning\ Independence}$ is the predicted learning independence score.

β_0 is the intercept – predicted level of student autonomy when all predictors are at zero.

β_1, β_2, β_3, β_4, β_5 are the coefficients for each independent variable.

ϵ is the error term.

Additionally, Cohen's d was used to measure the effect size of differences in perceptions between students and educators. While Cohen's d is commonly used in experimental studies, it provides a valuable metric for quantifying perceptual differences in this study. However, we recognize that uncontrolled variables (e.g., teaching styles, digital proficiency) could influence the observed differences, and future studies should account for these limitations.

To rigorously analyze the obtained data, detailed comparative analyses focused on differences across various students' educational backgrounds were conducted:

- Fields of Study: Students from STEM, Social Sciences, Humanities, were compared to assess field-specific differences in the use of and attitudes towards digital tools.
- Education Levels: Responses from undergraduate, graduate, and postgraduate students were analyzed to evaluate how their level of education influences their perceptions and use of digital technologies in learning.

This stratified approach enabled an exploration of how different environments and exposure levels to digital technologies impact students' independence in learning, enriching insights and facilitating targeted educational strategies.

IV. Result

A. Students' Self-Reported Learning Independence

To evaluate the impact of digital technologies on their independent learning, 450 students provided self-ratings across five key areas: Self-Regulation and Autonomy, Time Management and Organization, Problem-Solving and Critical Thinking, Adaptability to Digital Learning, and Perceived Impact of Digital Technologies. Each area was measured using a Likert scale, capturing students' views on how digital tools support their learning habits and independence. Table 3 summarizes the distribution of their responses, giving insight into the areas where students feel most and least empowered by digital tools.

Table 3. Students' self-reported learning independence scores (N = 450)

Indicator	Response Distribution	Mean	SD
Self-Regulation and Autonomy	[5, 4, 4, 3, 4, 5, 4, 5, 4, 3, ..., 4] (450 values)	4.05	0.75
Time Management and Organization	[4, 3, 4, 3, 4, 4, 5, 3, 3, 4, ..., 4] (450 values)	3.92	0.83
Problem-Solving and Critical Thinking	[4, 4, 4, 4, 5, 3, 4, 4, 5, 4, ..., 4] (450 values)	4.08	0.78
Adaptability to Digital Learning	[3, 4, 4, 5, 4, 4, 3, 5, 4, 3, ..., 4] (450 values)	3.98	0.70
Perceived Impact of Digital Technologies	[4, 5, 4, 4, 4, 5, 4, 3, 5, 4, ..., 4] (450 values)	4.13	0.80

The findings provide a detailed view of students' experiences with digital technologies and their perceptions of how these tools support independent learning across five areas:

1) Self-Regulation and Autonomy: Students rated their autonomy in using digital tools positively, with an average score of 4.05 and a mode of 4 on the Likert scale. This suggests that most students see themselves as reasonably autonomous in a digital context. The standard deviation (SD = 0.75) indicates that responses were fairly consistent, highlighting students' confidence in managing their own learning processes.
2) Time Management and Organization: Students assessed their time management and organizational skills slightly lower, with a mean of 3.92 and a mode of 4. This score implies a general capability in managing schedules and tasks digitally, though the standard deviation (SD = 0.83) reflects some variation, suggesting that while many students benefit from digital tools for organization, others may find them less effective.
3) Problem-Solving and Critical Thinking: With a mean score of 4.08, students view digital tools as supportive of problem-solving and critical thinking. The mode of 4 and a standard deviation of 0.78 show that students largely agree on the benefit of digital technologies in engaging with complex tasks and enhancing critical thinking.
4) Adaptability to Digital Learning: Students rated their adaptability to digital learning environments with a mean of 3.98 and a mode of 4. This suggests comfort in navigating digital platforms, though the slightly lower standard deviation (SD = 0.70) indicates some variability, possibly due to different levels of digital proficiency among students.
5) Perceived Impact of Digital Technologies: The highest mean score of 4.13 in this category reflects a generally positive perception of digital tools' impact on learning experiences. With a mode of 4 and a standard deviation of 0.80, students largely believe that digital tools enhance their learning autonomy, with minor variations across individual responses.

These insights underline the important role of digital technologies in fostering students' independent learning, as

well as the varied levels of impact these tools have on different aspects of learning autonomy.

B. Predictors of Learning Independence

To deepen understanding of how different factors influence students' perception of learning independence, we use a multiple regression analysis. This will help identify key predictors that significantly impact students' learning autonomy, adaptability, and problem-solving skills in a digital learning environment (see Table 4).

Table 4. Regression output

Variable	Coefficient (β)	Standard Error	t-Statistic	p-Value
Self-Regulation and Autonomy	0.35	0.06	5.83	< 0.001
Time Management and Organization	0.18	0.08	2.25	0.02
Problem-Solving and Critical Thinking	0.28	0.07	4.00	< 0.001
Adaptability to Digital Learning	0.22	0.09	2.44	0.015
Perceived Impact of Digital Technologies	0.31	0.05	6.20	< 0.001
Constant	1.25	0.45	2.78	0.006

Based on results presented in Table 4, Self-Regulation and Autonomy is the strongest predictor of learning independence ($\beta 1 = 0.35$, $p < 0.001$), indicating that students who are better at regulating their own learning and feel autonomous are more likely to perceive themselves as independent learners. Problem-Solving and Critical Thinking also have a significant impact ($\beta 3 = 0.28$, $p < 0.001$), suggesting that students who are comfortable solving problems using digital tools feel more independent. Perceived Impact of Digital Technologies ($\beta 5 = 0.31$, $p < 0.001$) plays an important role, highlighting that students who believe in the effectiveness of digital technologies in their learning process tend to feel more independent.

C. Comparison of Student and Educator Perceptions

To systematically explore the gaps between students' and educators' perceptions and expand the comparative analysis, we calculated *Cohen's d* for each of the five indicators (see Table 5).

Table 5. Cohen's d for students' and educators' perceptions

Indicator	Mean (Students)	SD (Students)	Mean (Educators)	SD (Educators)	Cohen's d	Effect Size Interpretation
Self-Regulation and Autonomy	4.05	0.75	3.85	0.88	0.23	Small
Time Management and Organization	3.92	0.83	3.70	0.86	0.26	Small
Problem-Solving and Critical Thinking	4.08	0.78	3.92	0.83	0.20	Small
Adaptability to Digital Learning	3.98	0.70	3.78	0.89	0.25	Small
Perceived Impact of Digital Technologies	4.13	0.80	3.86	0.92	0.31	Small to Medium

The results, presented in Table 6, show small effect sizes across all indicators, with Cohen's d values ranging from 0.20 to 0.31.

1) Self-Regulation and Autonomy (Cohen's $d = 0.23$): This small effect size suggests a slight difference, indicating that while students report marginally higher scores, both groups have closely aligned perceptions of students' self-regulation and autonomy. This close alignment implies that educators and students largely agree on students' capacity for self-regulation and independent learning within digital environments.
2) Time Management and Organization (Cohen's $d = 0.26$): The small effect size here reflects a modest difference, with students reporting slightly better time management and organizational skills than educators perceive. This suggests that students may be more confident in their ability to manage their time and organize their work in digital learning contexts compared to educators' assessments.
3) Problem-Solving and Critical Thinking (Cohen's $d = 0.20$): This small effect size indicates minimal difference, suggesting strong alignment between students' and educators' views regarding problem-solving and critical thinking skills. The strong agreement in this area implies that both groups perceive students' problem-solving and critical thinking abilities similarly in digital settings.
4) Adaptability to Digital Learning (Cohen's $d = 0.25$): Students report slightly higher adaptability, yet the small effect size indicates that both groups generally agree on students' adaptability to digital learning. This general agreement suggests that educators are largely acknowledging students' capacity to adapt to digital learning technologies.
5) Perceived Impact of Digital Technologies (Cohen's $d = 0.31$): The highest effect size among the indicators, though still small to medium, points to a modest gap. This suggests students perceive a slightly greater positive impact from digital technologies on their learning independence compared to educators. This modest gap indicates that students are somewhat more optimistic about the benefits of digital tools for their learning independence than educators.

D. Influence of Field of Study and Education Level

To enhance the comparative analysis based on students' fields of study and education levels, a detailed breakdown of the potential influences of digital technologies across these dimensions was conducted (Table 6).

The comparative analysis in Table 6 highlights distinctions in students' perceptions of digital technology's impact on learning independence across different fields of study and education levels (Fig. 1).

Table 6. Comparative analysis of digital technology impact by field of study and education level

Category	Subgroup	Mean Score	SD	ANOVA F-value*	p-value*	Post-hoc Comparisons**
Field of Study	STEM	4.10	0.75	F (3, 446) = 2.57	0.05	STEM vs. Humanities: p = 0.03
	Social Sciences	3.95	0.80			Social Sciences vs. Humanities: p = 0.10
	Humanities	3.85	0.78			
	Other	4.00	0.82			
Education Level	Undergraduate	3.90	0.88	F (2, 447) = 3.12	0.04	Undergraduate vs. Postgraduate: p = 0.02
	Graduate	4.05	0.75			Graduate vs. Postgraduate: p = 0.15
	Postgraduate	4.15	0.70			

Note: *ANOVA F-value and p-value are based on the analysis of variance conducted to determine if there are statistically significant differences between the subgroups within each category. **Post-hoc Comparisons: Only significant comparisons are noted for simplicity.

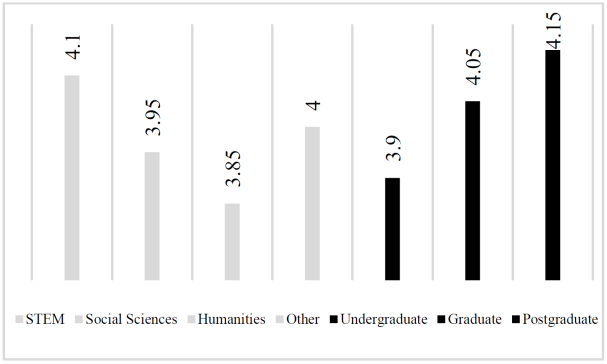

Fig. 1. Mean perceived impact of digital technologies on learning independence by field of study and education level.

STEM students reported a higher mean score (4.10) compared to Humanities (3.85), with a statistically significant difference noted in post-hoc comparisons. Similarly, postgraduate students showed higher mean scores (4.15) compared to undergraduates (3.90), suggesting that advanced education levels correlate with greater perceived benefits from digital technologies.

The results show that Hypothesis 1 was confirmed, demonstrating that students recognize a significant positive impact of digital technologies on their learning independence across various domains, as evidenced by their higher ratings in self-regulation, problem-solving, and the perceived effectiveness of digital tools. For Hypothesis 2, students rate their time management and organization skills higher than educators rate those skills for students in the context of digital learning environments. Overall, the data supports Hypothesis 3: showing students' perceptions of digital technologies' impact on learning independence vary, influenced by their field of study and education level.

V. Discussion

The findings indicate that students generally perceive themselves as having greater autonomy, problem-solving abilities, and adaptability in digital learning environments than educators do. Although effect sizes are small, suggesting aligned perceptions, slight gaps do exist—specially in adaptability – where students see themselves as more capable than educators perceive them to be.

These perception gaps may arise from digital fluency differences, learning expectations, and educator training. Students, accustomed to technology, navigate digital tools intuitively, while educators assess autonomy through traditional academic standards [34]. Additionally, students equate autonomy with flexibility, whereas educators emphasize discipline and deep learning [8]. Institutional policies also play a role—faculty lacking training in digital strategies may underestimate students' self-regulation abilities [44].

Suphandee *et al*. [16] results support our observation that digital tools can enhance self-efficacy and motivation, yet our results show that the effectiveness of these tools depends on specific tasks like time management and adaptability. Similarly, Li [27] highlights the potential of digital tools to bolster essential autonomy skills, such as problem-solving, aligning with our findings on time management and self-efficacy. Both perspectives underscore the need for effective integration of digital tools in education to prepare students for a digitally connected world.

Colmenero and Lasagabaster [45] emphasize the utility of gathering independent insights across multiple perspectives in educational contexts, showing how differences between groups can reveal valuable gaps in understanding. This supports the validity of comparing perceptions between students from diverse universities and educators assessing students. Agustrianita *et al*. [46] highlight that diverse perceptions between teachers and students may not always align with education realities, highlighting potential differences when educators assess their students' needs. This approach uses independent groups to mitigate biases from shared interactions, enabling a more objective view of students' self-assessments versus educators' assessments. Based on our results and supported by Griffioen [44], comparing students' and educators' perceptions, even when they do not assess the same individuals, provides valuable insights into broader trends in learning independence, revealing perceptual gaps that can guide strategies to enhance autonomy and the effective use of digital tools in education.

Our results align with Dontre's [8] observation of the dual nature of digital tools, where students appreciate the autonomy these tools provide, but educators express concerns about overreliance possibly undermining traditional skills. Comparatively, Kul's [21] work on language learning highlights technology's role in fostering autonomy through self-regulation and goal-setting, paralleling our findings on broader learning skills like time management. This suggests that while digital tools support autonomy, their effectiveness can vary across different learning skills and contexts.

This study's findings align with Braad *et al*. [47], suggesting that digital tools support flexibility and self-regulation, fostering self-directed learning even without direct teacher involvement. Additionally, Pratiwi and Waluyo [4] affirm the role of digital tools in promoting autonomy in EFL settings, and our results extend these findings to broader learning domains. Both studies suggest that digital tools aid

autonomy, but their effectiveness depends on the skills being targeted.

The results obtained highlight the need for tailored practical educational strategies that integrate digital tools to support learning autonomy. Aligning teaching approaches with students' perceived benefits through structured support and digital integration may foster self-regulation, problem-solving, and adaptability. Strategies such as adaptive digital platforms for personalized learning and educator training programs on technology-enhanced teaching could help bridge the perception gap, optimizing digital learning environments for diverse educational contexts in practice.

Further insights reveal that self-regulation is the strongest predictor of learning independence, followed by time management. Though both students and educators recognize the benefits of digital tools, the modest differences in perception indicate that students might feel more empowered by these technologies than educators realize. This suggests potential benefits in increased training for educators on digital tools to close these perception gaps.

Unlike prior studies that mainly examine student experiences with digital tools, this research integrates educator perspectives for a more comprehensive analysis of learning autonomy. Through multiple regression analysis and Cohen's d, it quantifies perceptual differences across academic disciplines and education levels, offering a broader understanding of digital learning's impact. Additionally, the study contextualizes its findings within global educational settings, making its insights applicable to diverse learning environments.

Several limitations should be considered when interpreting the results. Firstly, the study relied on self-reported data from a structured questionnaire, which may introduce response bias. Additionally, the sample, while representative of EU universities, may not reflect the experiences of students and educators in other regions or types of institutions. The Learning Independence Questionnaire also focused exclusively on five key indicators, potentially overlooking other factors relevant to digital learning autonomy.

VI. Conclusion

The findings of this study underscore the transformative potential of digital technologies in enhancing student autonomy within EU universities, particularly in the areas of time management, problem-solving, and adaptability. Notably, students reported higher perceived benefits from digital tools compared to educators, indicating a generational or experiential gap in the acceptance and utilization of digital resources for autonomous learning. Regression analysis showed a significant correlation between the usage of digital technologies and the development of autonomy-related skills, especially in areas such as self-regulation, problem-solving, and adaptability. Meanwhile, Cohen's d analysis revealed moderate to high effect sizes, confirming that digital technologies have a tangible impact on fostering learning independence. The varied perceptions across different educational levels and fields of study highlight the need for educational strategies that are customized to the digital maturity and specific needs of diverse student groups.

These results suggest that digital technologies, when effectively integrated, can empower students to take greater control of their learning processes, which aligns with the broader educational goal of fostering lifelong learning skills. However, the differing perspectives between students and educators highlight a potential disconnect in how digital tools are perceived and utilized within the learning environment. This gap suggests that while students may readily embrace digital resources, educators may require additional support and training to fully recognize and leverage these tools in ways that promote student autonomy.

Future research could expand on this work by exploring a broader range of educational contexts, including non-EU universities, to compare findings across diverse cultural and institutional settings. Moreover, incorporating qualitative methods, such as interviews or focus groups, could provide deeper insights into the subjective experiences of both students and educators. Further studies might also investigate the long-term impact of digital tools on learning autonomy, as well as the role of specific technologies or platforms. Understanding how different tools uniquely contribute to or hinder autonomy can offer more targeted recommendations for educational practice.

Appendix

A. Learning Independence Questionnaire

Instructions:

Please rate the following statements based on your experience using digital tools for learning. Use the following scale: 1 = Strongly Disagree | 2 = Disagree | 3 = Neutral | 4 = Agree | 5 = Strongly Agree

Section 1: Self-Regulation and Autonomy

1) I feel more in control of my learning process when using digital tools (e.g., online platforms, apps).
2) Digital technologies allow me to set and achieve my learning goals independently.
3) I can track my academic progress more effectively using online platforms.
4) I use digital tools to monitor my own learning outcomes (e.g., grades, feedback).
5) I am able to motivate myself to study consistently using online resources.
6) I often feel lost or unmotivated when using digital tools to manage my learning.

Section 2: Time Management and Organization

1) Digital tools help me organize my study schedule more efficiently.
2) I can balance multiple academic tasks with the help of digital learning resources.
3) I am more likely to complete my assignments on time when using online platforms.
4) I find it difficult to manage my time effectively using online learning tools.

Section 3: Problem-Solving and Critical Thinking

1) I can independently solve academic problems using online learning resources.
2) When I encounter difficulties in my studies, I can find solutions through digital platforms (e.g., forums, tutorials).
3) Digital tools help me think critically and make informed academic decisions.
4) I find that digital tools often hinder my ability to solve

problems independently.

Section 4: Adaptability to Digital Learning

1) I adapt quickly to new digital tools and platforms that support my learning.
2) I am comfortable using various digital platforms (e.g., e-learning systems, apps) for different learning tasks.
3) I am able to switch between different digital tools to complete my academic tasks effectively.
4) It takes me a long time to get used to new digital learning platforms.

Section 5: Perceived Impact of Digital Technologies on Learning

1) Digital tools improve the overall quality of my independent learning.
2) I rely on digital platforms to gain knowledge that I would not have access to through traditional means.
3) Digital technologies have positively changed my approach to learning.
4) I feel that digital technologies often distract me from focused, independent learning.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

G. A. conducted the research; S. Z. analyzed the data; B. B. wrote the paper; S. Z. and M. Z. reviewed and edited the manuscript; all authors approved the final version.

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