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Mapping Hungarian Secondary School Students' Digital and AI Literacy with a Focus on Language Learning

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Abstract

As digital technologies and artificial intelligence (AI) have been transforming education, students need to acquire the competencies necessary to use these tools critically and ethically. Although digital literacy has been extensively explored in higher education contexts, research on secondary school students remains limited. This study addresses this gap by researching Hungarian secondary school students' digital and AI literacy using the Digital Intelligence Framework (DQ Institute, 2019) and the Québec Digital Competency Framework (Conseil supérieur de l'éducation, 2019). An online questionnaire ($N = 130$) assessed six competency dimensions, including ethical AI use, critical evaluation, and communication. Quantitative data analysis was conducted using SPSS, through descriptive statistics, ANOVA, correlation, and regression. This study reveals that Hungarian secondary school students show varying levels of digital and AI literacy, with public school students demonstrating significantly higher awareness of AI ethics and digital responsibility compared to those in private or international schools. Students with advanced self-assessed English proficiency scored higher in digital communication and empathy, suggesting a link between language skills and digital competence. Additionally, lifelong learning attitudes strongly predicted confidence in using AI tools. These findings highlight the importance of tailored, ethically focused, and skill-integrated AI literacy education to prepare secondary students for digital environments. By applying the internationally recognised frameworks, this study informs educational policy and practice, advocating for targeted AI literacy and language learning curricula to foster equitable, ethically grounded digital skills in Hungarian secondary schools.

Keywords: digital literacy, AI literacy, digital competencies, language learning, secondary education

1. Introduction

The rapid integration of digital technologies and artificial intelligence (AI) into everyday life has transformed how students access, process, and produce information. In education, particularly in secondary schools, this transformation presents both opportunities and challenges. As students increasingly engage with generative AI tools and digital learning environments, there is a need to reframe our understanding of literacy to embrace not only

access and technical proficiency but also critical engagement, ethical responsibility, and creative use of digital tools (Marín & Castañeda, 2023; Naamati-Schneider & Alt, 2024). Within this context, digital literacy, which includes skills for using and critically evaluating digital tools and information, and AI literacy, which involves understanding, applying, and ethically navigating AI technologies, are evolving as essential competencies, particularly in language learning, where digital technologies influence communication, interaction, and content creation (Quraishi et al., 2024; Zhang & Zhang, 2024).

Recent research indicates that traditional literacy models are inadequate to address the complexities of digital involvement in the AI era (Tinmaz et al., 2022). Consequently, new frameworks have been proposed to guide curriculum design. Among these, the Digital Intelligence Framework (DQ Institute, 2019) and the Digital Competency Framework developed in Québec (Conseil supérieur de l'éducation, 2019) offer comprehensive, multidimensional models that include technical, cognitive, socio-emotional, and ethical competencies. These frameworks reject narrow, skill-based approaches and instead promote critical thinking, adaptability, and responsible innovation as core 21st-century skills.

Despite growing attention to these topics, most existing research has focused on university students or adults, with very limited empirical data available on the digital and AI literacy of secondary school learners. Moreover, there is a lack of studies focusing on comprehensive, multi-dimensional frameworks that reflect the complex nature of digital engagement.

This study aims to address these gaps by examining the digital and AI literacy of Hungarian secondary school students. By analysing questionnaire responses from a diverse student sample, the research investigates the extent to which learners demonstrate ethical AI use, digital responsibility, critical information evaluation, and communication skills. It also explores differences based on school type and self-assessed language proficiency.

2. Literature Review

Digital and AI tools have already been integrated into education, transforming how students access information, communicate, and engage in learning. As a result, digital and AI literacy have become essential competencies for students for navigating modern learning environments and preparing for future academic and professional challenges. However, varying definitions and conceptual models have led to fragmented research, with limited studies with findings based on multidimensional frameworks that represent the full complexity of these competencies. Traditional definitions of digital literacy once focused on basic technical skills, whereas contemporary interpretations have expanded to encompass critical thinking, ethical awareness, information evaluation, and responsible digital participation. Notably, AI literacy among secondary school students remains underexplored, without empirical evidence on how they engage with AI technologies in educational contexts.

This literature review aims to critically synthesize existing research on digital and AI literacy of students, with the goal of connecting findings with two robust and internationally recognised frameworks, the DQ Institute framework for digital citizenship (DQ Institute, 2019) and the Québec Digital Competency Framework (Conseil supérieur de l'éducation, 2019). These frameworks offer comprehensive models that include not only technical skills but also ethical use, critical thinking, digital communication, and personal empowerment. The review will

present an overview of these frameworks, summarise research on student's digital and AI literacy, compare themes across studies, and identify conceptual and methodological gaps.

2.1. Frameworks of Digital Literacy

2.1.1. Limitations of Well-known Frameworks

Internationally recognised frameworks address digital and AI competence from different angles, but many of them are educator- or policy-facing rather than student-centred for secondary contexts. DigCompEdu defines 22 educator competences in six areas (Professional Engagement, Digital Resources, Assessment, Teaching and Learning, Empowering Learners, Facilitating Learners' Digital Competence) with an A1-C2 progression, offering a strong map for teacher practice rather than students' literacy profiles (Redecker, 2017).

Recent UNESCO AI competency frameworks specify AI-era competences for students (12 competences across human-centred mindset, ethics, AI techniques, and system design; staged at Understand/Apply/Create) and for teachers (15 competences spanning ethics, AI foundations, AI pedagogy, and professional learning), but they are AI-specific, broad, and primarily intended as global policy references (UNESCO, 2024a; 2024b). The Common Framework of Reference for Intercultural Digital Literacies (CFRIDiL) is data-driven and multimodal, integrating Multimodal Orchestration, Digital Technologies, Intercultural Communication, and Transversal Skills, yet it was developed in higher-education settings and targets intercultural, multimodal assessment more than school-level digital citizenship (Sindoni et al., 2021). The Global Framework for Educational Competence in the Digital Age reframes competence through educator identities (Citizen/Teacher/Connector) and roles (Design, Facilitation, Assessment, Leadership, Collaboration, Mentoring), again centring teacher development (Sáez et al., 2020).

These frameworks offer valuable but partial focus: several are educator-centred and policy-oriented, others are AI-specific or rooted in higher-education intercultural assessment, and few provide operational guidance for investigating secondary students' digital and AI literacies within language-learning contexts. They also tend to leave open issues of contextualisation (e.g., school type, linguistic proficiency), measurement (student-level indicators, invariance across groups), and the integration of ethics into everyday classroom practice. This posits the need for a more comprehensive, context-sensitive framework that unifies cognitive, ethical, socio-emotional, and creative dimensions of digital and AI literacy, and can be practically implemented and assessed in secondary language education.

2.1.2. The Need for a Reviewed, Comprehensive Framework

The increasing integration of digital technologies in education has prompted scholars and policymakers to propose a wide range of frameworks to define and foster digital literacy. However, the diversity of these models has also led to conceptual fragmentation and inconsistencies in how digital literacy is understood and operationalized. In a recent meta-synthesis, Marín and Castañeda (2023) analysed reviews of digital literacy frameworks (*N=33*), with the emphasis on strategies to foster digital literacy skills in education. Their main findings emphasize that digital literacy is not a singular or static skill, but a combination of practices, including technological, intellectual, attitudinal, and ethical dimensions, and it has evolved into critical, reflective, and participatory citizenship frameworks. Despite these advances, the authors point out that many widely adopted international frameworks fail to address the

multidimensional and context-sensitive nature of digital literacy. They note a tendency to conceptualize digital literacy as an individual competence, thereby neglecting its inherently collective and socio-cultural dimensions. This critique is reaffirmed by Tinmaz et al. (2022), who conducted a systematic review of academic papers (*N=43*) and similarly called for the development of more context-sensitive and regularly updated frameworks, and they suggested the use of digital literacy strategies to support broader goals such as equity, health, and workforce readiness.

In response to these identified gaps, Hammoda and Foli (2024) proposed a conceptual model designed to be learner-centred and adaptable to contemporary digital realities, the Digital Competence Framework for Learners. Their framework includes seven competency areas, two of which have never been addressed as separate competencies: Devices and Software Operations and Career-related Competencies. The rationale behind the former area is that mobile learning is growing, and distinct skills are required to operate each platform effectively, while the latter was added to address employability and job-readiness, as a response to the demand for students to build career identity in digital spaces. Although this presents a promising evolution toward a more comprehensive and learner-responsive model, it is not without limitations. As a conceptual framework, it has yet to be empirically validated, and its applicability may vary across educational contexts and digital infrastructures. Its success may depend on factors such as national curricula, access to technology, and institutional support, which raises concerns about scalability and equity.

The reviews and proposals explain a clear need for flexible, empirically grounded, and socially responsive frameworks that can advance alongside emerging technologies and the changing needs of learners. The development and adoption of such frameworks should prioritize not only technical skill development but also critical engagement, ethical awareness, and social participation in digital environments.

2.1.3. The Digital Intelligence Framework

Developed by the DQ Institute (2019), the Digital Intelligence Framework offers a comprehensive, research-based model that outlines the key competencies individuals need to navigate the digital world safely, responsibly, and effectively. As one of the most holistic digital literacy frameworks currently available, it was developed as a global standard and is increasingly used in educational, policy, and organizational contexts. The framework is structured around eight interconnected areas: digital identity, use, safety, security, emotional intelligence, communication, literacy, and rights. These categories are further organised into four levels – Digital Connectivity, Digital Citizenship, Digital Creativity, and Digital Competitiveness – corresponding to an individual's developmental stage and engagement with digital technology.

The DQ Framework explicitly addresses many of the limitations identified in recent literature. It goes beyond basic digital proficiency by integrating technical skills with social, emotional, cognitive, and ethical dimensions. This corresponds closely to the calls by Marín and Castañeda (2023) and Tinmaz et al. (2022) for frameworks that move past individualistic, decontextualized definitions of digital literacy. For instance, DQ's inclusion of digital emotional intelligence and digital rights and responsibilities positions it as a framework that recognizes the collective and societal implications of digital participation.

Furthermore, the DQ Framework is designed to be flexible and adaptable across cultures and educational systems, offering implementation guides and assessment tools that can be localised. This adaptability addresses the concern raised in the literature that many frameworks lack contextual relevance and fail to evolve with the rapidly changing digital landscape (Hammoda & Foli, 2024; Marín & Castañeda, 2023; Tinmaz et al., 2022). Its emphasis on digital creativity and competitiveness also aligns with emerging needs for future-oriented skills, including AI interaction, content creation, and ethical innovation.

2.1.4. The Québec Digital Competency Framework

The Digital Competency Framework, developed by the Conseil supérieur de l'éducation (2019), represents a comprehensive, competency-based approach to supporting the effective integration of digital technologies across all levels of education, from preschool to higher education and vocational training. The framework is intended to promote lifelong learning and skill development for both students and educators. Its primary objective is to cultivate digital competency, defined as "a set of skills necessary to the confident, critical and creative use of digital technologies to achieve objectives with regard to learning, work, leisure, and inclusion or participation in society" (Conseil supérieur de l'éducation, 2019, p. 7). The framework encourages autonomy in digital tool usage and supports individuals in selecting appropriate technologies for specific tasks. In addition, it highlights the need for adaptability in response to technological advancements such as artificial intelligence.

One of the framework's key strengths lies in its future-oriented and adaptable design, addressing the very limitations highlighted in recent critiques of digital literacy models. As noted by Marín and Castañeda (2023) and Tinmaz et al. (2022), many existing frameworks lack the flexibility to remain relevant in developing technological landscapes. The Québec framework responds to this challenge by explicitly encouraging autonomy and critical evaluation in digital tool selection and use, with particular attention to emerging technologies such as artificial intelligence. Rather than prescribing a fixed skill set, it empowers learners to make context-sensitive decisions and to adopt new tools as needed.

The framework adopts a competency-based model, interpreting "competency" as the complex ability to apply internal and external resources effectively across various situations. This approach corresponds to the multidimensional perspective on digital literacy, incorporating not only technical knowledge but also cognitive flexibility, creative thinking, and ethical awareness. Moreover, it acknowledges that competencies are interrelated and non-linear, developing over time in response to individual growth, changing contexts, and new technological opportunities. Therefore, the framework is intentionally designed to be flexible and future-proof, capable of accommodating ongoing innovations in digital tools and practices. It rejects a fixed or hierarchical structure, instead promoting a cyclical process of lifelong learning.

Importantly, the Québec framework avoids a rigid hierarchical structure, which distinguishes it from many traditional digital literacy taxonomies. Instead, it embraces the fluidity and interconnectedness of digital skills and attitudes, encouraging learners and educators to integrate competencies in various combinations depending on specific tasks or environments.

This flexibility, scalability, and learner-centred orientation make the Québec framework particularly suited for guiding both pedagogical practices and empirical research. It directly supports broader educational goals, such as adaptability, equity, innovation, and critical digital

engagement, thus addressing many of the gaps identified in prior reviews of digital literacy frameworks.

2.1.5. Comparative Synthesis: Aligning the DQ and Québec Frameworks

Both the Digital Intelligence Framework (DQ Institute, 2019) and the Digital Competency Framework (Conseil supérieur de l'éducation, 2019) represent significant advances in conceptualizing digital literacy as a multidimensional, context-sensitive, and future-oriented competence. These frameworks converge in key aspects that make them particularly relevant for addressing the gaps highlighted in recent reviews of digital literacy literature (e.g., Marín & Castañeda, 2023; Tinmaz et al., 2022).

Both frameworks explicitly reject narrow, skill-based definitions of digital literacy in favour of holistic and developmental models. They incorporate cognitive, ethical, emotional, and social competencies, responding to earlier critiques that many frameworks overlook the broader social and moral dimensions of digital participation. Additionally, both emphasize critical engagement with digital tools and stress the importance of adaptability in response to evolving technologies such as artificial intelligence. Another common strength is their flexibility and scalability. Neither model proposes a fixed hierarchy of competencies; instead, they are structured to allow learners to progress at different paces and adapt their skill sets to various contexts.

Despite their shared vision, the frameworks diverge in emphasis and structure. The DQ Framework is organised around eight core areas and four progressive levels, offering a developmental arc that parallels with stages of digital engagement. In contrast, the Québec Framework adopts a competency-based model that avoids strict hierarchical progression. It is grounded in a pedagogical tradition, emphasizing lifelong learning, autonomy, and context-specific application. Although it includes many of the same dimensions as the DQ model, it focuses more on learner agency, flexibility, and the integration of digital tools into meaningful educational tasks. The DQ Framework may be stronger in addressing global policy alignment and standardized assessment. Meanwhile, the Québec Framework provides richer pedagogical scaffolding, making it particularly suitable for curriculum development and integration across formal education systems.

Together, these frameworks offer a complementary perspective on digital and AI literacy, particularly in student populations. Mapping student competencies against both models allow for a more nuanced analysis of how learners develop digital and AI literacy across cognitive, technical, and ethical domains. Using both frameworks together can help researchers and educators bridge the gap between high-level visions and everyday pedagogical realities, fostering approaches that are both theoretically grounded and practically adaptable.

2.2. Students' Digital and AI Literacy

There has been substantial research on higher education students' digital literacy skills. In a mixed-method study involving 130 university students and 20 lecturers, Quraishi et al. (2024) found that the integration of digital literacy skills into higher education significantly improves

students' academic learning outcomes. However, they found that usage trends show strong dependence on productivity and e-learning tools, but limited adoption of emerging technologies like AI. Their research supported the study by Ervianti et al. (2023), whose findings also

demonstrated a strong correlation between digital literacy and academic achievement. Their quantitative study indicated that over 76% of the variation in learning outcomes could be explained by digital literacy levels (*N*=49). Both studies emphasise the importance of redesigning curricula with the integration of digital literacy to foster the skills that students will need to thrive in their future life, offering ongoing training and support for students to develop critical digital competencies. This implication is also suggested by Marín and Castañeda (2023), who argue that it must be integrated across subjects and disciplines, and treated as a collective educational goal.

The evolving role of AI in education further complicates this landscape. A quantitative study by Zhang and Zhang (2024) investigates the opportunities, challenges, and consequences of integrating artificial intelligence (AI) into teacher education (*N*=202). The study found that AI streamlines administrative tasks like grading and attendance, AI tools enable personalized, adaptive learning for students with diverse needs, and that AI boosts teachers' digital competence. Although their findings are positive, they identify some challenges, such as inequitable access to AI tools, and the need for ongoing AI-focused professional development.

Adding a critical dimension, Naamati-Schneider and Alt (2024) conducted a mixed-method study (*N*=223; 441 observations) exploring how AI is reshaping digital literacy itself. Their results show a shift from basic skills toward evaluation, understanding information bias, effective prompting and critical AI use. The authors posit the need for a balanced hybrid model combining AI use with traditional digital literacy skill-building.

Dringó-Horváth et al. (2025) present a pioneering large-scale study on Hungarian university teachers' digital competence and AI literacy, drawing from a weighted sample (*N*=1103) to explore how these competencies interrelate and are moderated by factors such as gender, age, teaching experience, and field of study. The research demonstrates a positive correlation between digital skills and AI proficiency, endorsing tailored educational strategies that account for demographic variances, such as stronger links among male educators in technical fields, while contributing empirical insights to global frameworks like DigCompEdu and UNESCO's AI Competency Framework. However, a notable limitation lies in its focus on higher education instructors, interpreting the findings less generalizable to secondary school contexts where students, rather than teachers, are the primary users navigating AI tools.

Folmeg et al. (2024) explore Hungarian higher education students' perceptions of ChatGPT to identify components of AI literacy as a critical 21st-century skill. Through qualitative analysis of responses from 69 students across six Hungarian universities, the study reveals that students primarily use ChatGPT for tasks like brainstorming, text creation, and translation, while highlighting challenges such as generic responses and outdated information. The findings underscore the need for systematic AI literacy integration in academic curricula and emphasising critical evaluation and ethical use. However, the study's focus is limited to higher education students, predominantly in business-related fields, which restricts its applicability to secondary school students.

Szabó et al. (2023) explore the real-time experiences of Hungarian youth (aged 15–29) with digital education during the COVID-19 pandemic, utilizing a social listening methodology to analyse online discourse and focus group data. The study reveals a dual perception: positive sentiments tied to easier performance evaluations (e.g., simpler exams) contrast with negative

views on learning effectiveness, eroded social relationships, and challenges with pandemic regulations like mask-wearing. This research offers valuable insights into how the pandemic reshaped educational experiences, highlighting persistent shifts toward online interactions and exposing infrastructural and social inequalities, particularly in Hungary's struggling education system. However, its focus spans both secondary and higher education students, with significant emphasis on university experiences, limiting its specificity for secondary school students.

The reviewed studies emphasise the complexity of digital and AI literacy in educational contexts. The agreement among researchers calls for the need for curricula that embed digital competencies across subjects and promote lifelong learning strategies.

2.3. Identified Gaps and Research Questions

As stated above, a number of studies have explored the digital literacy skills of students, particularly within the context of higher education (Ervianti et al., 2023; Naamati-Schneider & Alt, 2024; Quraishi et al., 2024; Zhang & Zhang, 2024). Consequently, a notable gap remains in understanding the digital and AI literacy skills of secondary school students, a group equally impacted by the increasing integration of digital technologies and AI tools in education.

Moreover, these studies have broadly examined digital literacy skills, often overlooking their application in specific educational domains. One such under-explored area is language learning, where the use of digital and AI tools is escalating. Despite the growing availability of AI-powered language learning applications, little empirical research has examined how secondary students engage with these tools or how they develop and apply relevant digital and AI literacies in this context.

These two key gaps form the basis of the present study, driven by the following research questions:

RQ1: To what extent do Hungarian secondary school students demonstrate awareness of ethical and responsible AI use?

RQ2: To what extent do Hungarian secondary school students engage in verifying online information and questioning digital sources?

RQ3: Do students from different Hungarian secondary school types differ significantly in AI ethics and digital responsibility?

RQ4: To what extent does self-assessed English language level influence digital communication and empathy skills?

This study addresses these questions to provide insights into the digital and AI literacy of Hungarian secondary school students, with a focus on their application in language learning contexts. The findings aim to guide the development of curricula that integrate ethical and critical digital competencies across diverse educational settings.

3. Methods

This study employed a quantitative survey design to investigate the digital and AI literacy skills of secondary school students in Hungary in connection with their language learning practices. The research was guided by two comprehensive frameworks, the Digital Intelligence Framework (DQ Institute, 2019) and the Digital Competency Framework (Conseil supérieur de l'éducation, 2019).

3.1. Instrument

Data were collected through an online questionnaire specifically designed for this study, with items designed based on the key concepts of the Digital Intelligence Framework (DQ Institute, 2019) and the Digital Competency Framework (Conseil supérieur de l'éducation, 2019), assessing competencies such as ethical AI use, critical evaluation, digital communication, and adaptability. The questionnaire included 49 Likert-scale items, 5-point scale (1 = Strongly Disagree, 5 = Strongly Agree), grouped into six theoretical constructs: ethical use and digital responsibility, critical evaluation and information literacy, personalisation prompting and content adaptation, communication and empathy, confidence in AI use, and lifelong learning and adaptability. These constructs were developed to reflect the frameworks' emphasis on technical, cognitive, ethical, and socio-emotional dimensions of digital and AI literacy, particularly in the context of language learning. Below are descriptions of the constructs and sample items:

- Ethical Use and Digital Responsibility: Measures awareness of ethical AI practices and responsible digital behaviour, addressing RQ1 (e.g., "I understand the ethical implications of using AI-generated content during school assignments"; "I always properly cite the sources I use"; "I respect copyright when using AI-generated materials").
- Critical Evaluation and Information Literacy: Assesses ability to verify online information and question digital sources, to answer RQ2 (e.g., "When I read English-language online articles, I always check if the information is reliable"; "When I read English language social media posts, I always check their authenticity"; "I recognize if content generated by AI contains misleading information").
- Personalisation Prompting and Content Adaptation: Evaluates skills in customizing AI tools for learning needs (e.g., "I confidently compare different sources before using them in my schoolwork"; "I use various AI applications confidently to improve my English language learning").
- Communication and Empathy: Examines effective and empathetic digital communication, linked to RQ4 (e.g., "I know how to adjust my tone in online English messages"; "I confidently express my opinion in English in online discussions").
- Confidence in AI Use: Measures self-assessed confidence in using AI tools effectively (e.g., "I am able to solve minor technical problems while using AI tools").
- Lifelong Learning and Adaptability: Evaluates attitudes toward continuous learning and adapting to new digital tools (e.g., "I effectively manage my time when I use AI tools for studying").

Demographic data such as age, gender, grade level, school type, and self-assessed English proficiency (beginner, intermediate, advanced) were also collected. These data enable

comparisons across student groups, such as differences in digital and AI literacy by school type or English proficiency levels.

3.2. Participants and Data Collection

The online questionnaire was distributed using Google Forms and was accessible for a period of three weeks in April 2025. Links to the survey were sent via email or shared by teachers in participating schools. Informed consent was obtained from all participants and their parents via an introductory section in the questionnaire. The study was designed to ensure anonymity and confidentiality throughout, with no personal data collected. Ethical approval was obtained from the relevant university body prior to the commencement of data collection.

One school refused to participate due to scheduling constraints. A total of 131 secondary school students participated in the study. One response was excluded due to incomplete data, resulting in a final sample of 130 responses for analysis. Participants were recruited from private, international, and public secondary schools across Hungary, including institutions in the capital city of Budapest and rural areas, to ensure a diverse representation of educational contexts, through institutional contacts and teacher networks. The sample included students aged between 14 and 19 (*M=16,19, SD=1,24*) from multiple year levels (9-12 grade). Participation was voluntary and anonymous.

3.3. Data Analysis

All statistical analyses were conducted using SPSS. After cleaning and excluding incomplete responses, descriptive statistics were generated for each construct, and a composite score was computed as the mean of its items, with higher scores indicating greater competence in that domain. Internal consistency reliability for each construct was assessed using Cronbach's alpha, with all values exceeding the acceptable threshold of $\alpha > .70$. Independent samples t-tests, one-way ANOVA with post hoc tests, one-way MANOVA, and Pearson correlation analyses were conducted to explore relationships between variables. Additionally, multiple linear regression was used to identify predictors of key outcomes, such as confidence in AI use.

4. Results

4.1. Scale Reliability and Validity

Internal consistency was acceptable to excellent across the six scales ($\alpha = .717 - .874$ see Table 1). Item diagnostics indicated that no removals were necessary; in a few cases, dropping a borderline item would have increased α trivially (e.g., AI Ethics to .804).

TABLE 1. SCALE RELIABILITY SUMMARY

Construct (5-point Likert)	Items (n)	Valid N	Cronbach's α
AI Ethics & Digital Responsibility	10	126	.793
Critical Evaluation & Information Literacy	8	128	.810
AI Personalisation, Prompting & Content Adaptation	5	126	.720
Communication & Empathy in Digital Spaces	7	125	.742
Lifelong Learning & Adaptability	8	123	.874
General AI Use Confidence	5	126	.717

Source: author's analysis based on questionnaire data (2025), SPSS output

Note. All scales were computed as the mean of their items (1 = strongly disagree, 5 = strongly agree); higher scores reflect greater competence. Cronbach's α values were calculated after item screening (corrected item–total r ≥ .30).

4.2. RQ1: To what extent do Hungarian secondary school students demonstrate awareness of ethical and responsible AI use?

Descriptive statistics for the AI Ethics & Digital Responsibility scale are reported in Table 2 (5-point scale; higher = greater ethical awareness). These values provide the overall level and spread of students' self-reported ethical engagement with AI.

TABLE 2. SIGNIFICANT ANOVA RESULTS FOR AI ETHICS & DIGITAL RESPONSIBILITY

Construct	Independent Variable	F(df1, df2)	*p*-value	η^2	Post hoc (significant)
AI Ethics & Digital Responsibility	School Type	5.09 (2, 127)	.008*	.074	Public school > Private school

Source: author's analysis based on questionnaire data (2025), SPSS output

Note. $p < .05$ (*). Values represent one-way ANOVA results. η^2 indicates effect size (partial eta squared).

Ethical awareness showed a strong, positive correlation with Critical Evaluation & Information Literacy, $r(130) = .763$, $p < .001$, indicating that students who report stronger source-checking and evaluative habits also report more responsible AI use. A multiple regression examined whether critical evaluation and AI personalisation/prompting predict ethical awareness. The model was significant, $F(2, 127) = 91.83$, $p < .001$, explaining 59.1% of the variance ($R^2 = .591$, adj. $R^2 = .585$). Critical evaluation was a unique, strong predictor ($\beta = .703$, $p < .001$), whereas AI personalisation showed a non-significant trend ($\beta = .115$, $p = .086$) (see Table 3).

TABLE 3. REGRESSION PREDICTING CRITICAL EVALUATION & AI PERSONALISATION

Predictor	B	SE B	β	*t*	*p*
(Constant)	1.108	0.224	—	4.95	<.001
Critical Score	0.650	0.061	.703	10.58	<.001
Personalisation Score	0.100	0.058	.115	1.73	.086

Source: author's analysis based on questionnaire data (2025), SPSS output

An independent-samples t-test found no gender difference on the AI Ethics & Digital Responsibility scale (see Table 4). (School-type differences in ethics are reported under RQ3.)

TABLE 4. T-TEST RESULTS FOR AI ETHICS AND DIGITAL RESPONSIBILITY

Construct	*t*(df)	*p*-value	Cohen's *d*	Significant?
AI Ethics & Digital Responsibility	$t(89) = 0.28$	.784	0.06	No

Source: author's analysis based on questionnaire data (2025), SPSS output

4.3. RQ2: To what extent do Hungarian secondary school students engage in verifying online information and questioning digital sources?

An independent-samples *t*-test showed a significant gender difference: males (M = 3.92, SD = 0.59) scored higher than females (M = 3.67, SD = 0.70) on critical evaluation and information literacy, $t(85) = 2.07$, $p = .042$, Cohen's $d = .38$ (Table 5). No other gender differences for this construct were observed.

TABLE 5. T-TEST RESULTS FOR CRITICAL EVALUATION AND INFORMATION LITERACY

Construct	*t*(df)	*p*-value	Cohen's *d*	Significant?
Critical Evaluation & Information Literacy	$t(85) = 2.07$	.042*	0.38	Yes

Source: author's analysis based on questionnaire data (2025), SPSS output

Note. $p < .05$ (*). Values represent two-tailed significance. Cohen's *d* represents effect size.

Critical evaluation displayed robust, positive associations with related competencies (Table 6): it correlated strongly with AI Ethics & Digital Responsibility ($r = .763$, $p < .001$) and Communication & Empathy in Digital Spaces ($r = .674$, $p < .001$), and moderately with General AI Use Confidence ($r = .413$, $p < .001$) and Lifelong Learning & Adaptability ($r = .346$, $p < .001$). Taken together, these links suggest that students who more consistently verify information and question sources also tend to report more ethical AI practices, richer digital communication, greater confidence using AI, and stronger learner agency.

TABLE 6. CORRELATION RESULTS (N=130)

Variable 1	Variable 2	*r*	*p*	Interpretation
Critical thinking	AI ethics	.763	< .001	Strong positive relationship
Critical thinking	Lifelong learning	.346	< .001	Moderate positive relationship
Critical thinking	AI confidence	.413	< .001	Moderate positive relationship
Communication	Critical thinking	.674	< .001	Strong positive relationship

Source: author's analysis based on questionnaire data (2025), SPSS output

4.4. RQ3: Do students from different Hungarian secondary school types differ significantly in AI ethics and digital responsibility?

A one-way ANOVA showed a significant effect of school type on AI Ethics & Digital Responsibility, $F(2, 127) = 5.09$, $p = .008$, $\eta^2 = .074$ (medium effect). Post hoc comparisons indicated that public-school students ($M = 4.09$, $SD = 0.58$) scored significantly higher than private-school students ($M = 3.74$, $SD = 0.63$); differences involving other school types were not statistically significant (Table 7). These results suggest that institutional context is associated with students' self-reported ethical awareness and responsible AI use.

TABLE 7. SIGNIFICANT ANOVA RESULTS FOR AI ETHICS AND DIGITAL RESPONSIBILITY

Construct	Independent Variable	F(df1, df2)	*p*-value	η^2	Post hoc (significant)
AI Ethics & Digital Responsibility	School Type	5.09 (2, 127)	.008*	.074	Public school > Private school

Source: author's analysis based on questionnaire data (2025), SPSS output

Note. $p < .05$ (*). Values represent one-way ANOVA results. η^2 indicates effect size (partial eta squared).

To examine whether school type relates to a broader pattern across the six literacy constructs, a one-way MANOVA was conducted. The multivariate effect was significant (Pillai's Trace = .173, $F(12, 246) = 1.94$, $p = .031$; Wilks' $\Lambda = .831$, $F(12, 244) = 1.97$, $p = .027$; Hotelling's Trace = .200, $F(12, 242) = 2.01$, $p = .024$; Roy's Largest Root = .177, $F(6, 123) = 3.63$, $p = .002$), indicating that school type differentiates the combined profile of digital/AI literacy competencies (Table 8).

TABLE 8. MANOVA TEST RESULTS FOR SCHOOL TYPE

Test	F	Hypothesis df	Error df	*p*-value	Interpretation
Pillai's Trace	1.935	12	246	.031	Significant
Wilks' Lambda	1.974	12	244	.027	Significant
Hotelling's Trace	2.013	12	242	.024	Significant
Roy's Largest Root	3.630	6	123	.002	Highly significant

Source: author's analysis based on questionnaire data (2025), SPSS output

4.5. RQ4: To what extent does self-assessed English language level influence digital communication and empathy skills?

A one-way ANOVA showed a significant effect of English proficiency on Communication & Empathy, $F(2, 126) = 3.80$, $p = .025$, $\eta^2 = .057$. Post-hoc comparisons indicated that advanced students (M = 3.97, SD = 0.63) scored significantly higher than beginner students (M = 3.50, SD = 0.75); other pairwise differences were not significant (Table 9).

TABLE 9. SIGNIFICANT ANOVA RESULTS

Construct	Independent Variable	F(df1, df2)	*p*-value	η^2	Post hoc (significant)
Communication & Empathy in Digital Spaces	Language Level	3.80 (2, 126)	.025*	.057	Advanced level > Beginner level

Source: author's analysis based on questionnaire data (2025), SPSS output

Note. $p < .05$ (*). Values represent one-way ANOVA results. η^2 indicates effect size (partial eta squared).

For context, an independent-samples *t*-test showed females outperformed males on this construct, $t(92.44) = 3.29$, $p = .001$, $d = .65$ (Table 10); this effect is reported here to situate the proficiency finding within observed subgroup variation.

TABLE 10. T-TEST RESULTS FOR COMMUNICATION AND EMPATHY

Construct	*t*(df)	*p*-value	Cohen's *d*	Significant?
Communication & Empathy in Digital Spaces	$t(92.44) = 3.29$	.001**	0.65	Yes

Source: author's analysis based on questionnaire data (2025), SPSS output

Note. $p < .01$ (**). Values represent two-tailed significance. Cohen's *d* represents effect size.

Communication & Empathy correlated strongly with Critical Evaluation ($r = .674$, $p < .001$) and AI Ethics & Responsibility ($r = .629$, $p < .001$), and moderately with AI Confidence ($r = .334$, $p < .001$) and AI Personalisation ($r = .434$, $p < .001$) (Table 11), indicating that higher communicative competence co-occurs with stronger evaluative and ethical engagement online.

TABLE 11. CORRELATION RESULTS (N=130)

Variable 1	Variable 2	*r*	*p*	Interpretation
Communication	Critical thinking	.674	< .001	Strong positive relationship
Communication	AI ethics	.629	< .001	Strong positive relationship
Communication	AI confidence	.334	< .001	Moderate positive relationship
Personalisation	Communication	.434	< .001	Moderate positive relationship

Source: author's analysis based on questionnaire data (2025), SPSS output

4.6. Supplementary Analysis

4.6.1. Predictors of AI Use Confidence

A linear regression was conducted to examine whether lifelong learning, communication, and critical digital literacy significantly predict students' confidence in using AI tools (see Table 12.). The overall model was statistically significant, $F(3, 126) = 62.12$, $p < .001$, and explained approximately 59.7% of the variance in confidence scores ($R^2 = .597$, Adjusted $R^2 = .587$). Only lifelong learning was a significant predictor ($p < .001$), suggesting that higher lifelong learning competencies are strongly associated with increased confidence in AI use.

TABLE 12. REGRESSION PREDICTING CONFIDENCE

Predictor	B	SE B	β	*t*	*p*
(Constant)	0.386	0.300	—	1.28	.201
Critical Score	0.153	0.094	.129	1.63	.105
Communication Score	0.080	0.092	.067	0.87	.387
Lifelong Learning Score	0.657	0.057	.692	11.46	<.001

Source: author's analysis based on questionnaire data (2025), SPSS output

4.6.2. Predictors of AI Personalisation, Prompting & Content Adaptation

A model was tested to predict the ability to personalize AI tools from students' lifelong learning and confidence scores (see Table 13). The model was statistically significant, $F(2, 127) = 77.57$, $p < .001$, explaining 55.0% of the variance ($R^2 = .550$, Adjusted $R^2 = .543$). Both predictors were significant ($p < .001$), indicating that students who are confident and engage in lifelong learning are more likely to personalize AI tools effectively for their learning needs.

TABLE 13. REGRESSION PREDICTING AI PERSONALISATION, PROMPTING & CONTENT ADAPTATION

Predictor	B	SE B	β	*t*	*p*
(Constant)	1.366	0.202	—	6.75	<.001
Confidence Score	0.370	0.081	.415	4.58	<.001
Lifelong Learning Score	0.320	0.077	.377	4.16	<.001

Source: author's analysis based on questionnaire data (2025), SPSS output

5. Discussion

5.1. Interpretation of the Results

The findings of this study offer new insights into secondary school students' digital and AI literacy within the Hungarian educational context, guided by the Digital Intelligence Framework (DQ Institute, 2019) and the Digital Competency Framework (Conseil supérieur de l'éducation, 2019). These results address the identified gaps in the literature, particularly regarding how digital and AI literacy are established at the secondary level and within language learning contexts. Overall, the pattern of results supports a holistic view of digital and AI literacy as a combination of ethical,

evaluative, communicative, and adaptive capacities rather than a set of isolated skills. The findings also emphasise the importance of context (school type) and learner characteristics in developing students' literacy skills. For language learning, this calls for the integration of digital and AI aims directly into language outcomes (reading-to-write, interaction, mediation), using tasks that blend language work with evaluation, creation, and reflection. Teachers can make these competencies visible in lesson objectives and assess them formatively via short reflections, prompt-revision logs, and peer feedback notes.

Ethical and responsible AI use (RQ1) is tightly linked to critical evaluation. Ethical awareness correlated strongly with critical evaluation and was uniquely predicted by it in regression models, explaining a considerable distribution of variance. This supports both frameworks, which position critical judgement and responsible participation as core to digital citizenship. The relation suggests that ethics education is likely to be most effective when embedded in tasks that require students to question sources, identify bias, and examine AI outputs, rather than taught as stand-alone rules.

With regard to verifying online information and questioning digital sources, results suggest a relatively high level of critical awareness among students. Beyond its association with ethics, critical evaluation related positively to communication, confidence, and lifelong learning. This pattern is consistent with the frameworks' emphasis on interdependence among competencies: students who regularly check credibility also communicate with greater sensitivity online, feel more capable with AI, and approach new tools with a growth orientation. The gender difference observed for critical evaluation and for communication/empathy indicates meaningful variability worth monitoring in classroom practice and future research.

The results confirm that institutional context matters (RQ3). Public-school students reported higher AI ethics and responsibility than peers in private schools, and MANOVA showed a multivariate school-type effect. These differences may reflect curricular emphasis, assessment practices, or school-wide norms around technology use. The results strengthen the case for whole-school approaches that integrate ethics, evaluation, and creative digital practice across subjects, not only within ICT lessons.

Language proficiency is associated with communicative–empathetic competence (RQ4). Students with higher self-assessed English proficiency scored higher on digital communication and empathy, and this construct, in turn, correlated with ethics, critical evaluation, confidence, and personalisation. In a language-learning context, this finding suggests an upright cycle: broader access to English-language digital spaces may support richer communicative repertoires and intercultural perspectives, which both frameworks treat as foundational to responsible, participatory digital citizenship.

A developmental sequence emerges from the supplementary models. Lifelong learning/adaptability was the dominant predictor of AI confidence; together, lifelong learning and confidence predicted AI personalisation. It offers a practical design logic for curricula: develop adaptive learning habits, scaffold confident tool use, and then turn that confidence into creative, ethically informed production.

Overall, the findings support a holistic view of digital and AI literacy as a combination of cognitive, ethical, emotional, and communicative skills, in line with both the Digital Intelligence Framework and the Digital Competency Framework. Importantly, the study confirms that demographic and contextual variables, particularly language proficiency and

school environment, influence how these skills are developed and applied. These insights call for personalised pedagogical strategies that reflect the realities of students' digital lives while promoting critical engagement and ethical AI use.

5.2. Limitations

The findings of this study contribute meaningfully to the understanding of secondary school students' digital and AI literacy, however, several limitations must be acknowledged. First of all, participants were recruited from Hungarian secondary schools via institutional contacts and teacher networks, which constitutes convenience sampling. Although public, private, and international schools from both Budapest and rural regions were included, data sizes were uneven across school types, limiting power for some contrasts and inflating standard errors. Future research should also include school-level covariates (e.g., ICT infrastructure, AI-related policy, assessment practices).

English proficiency was self-assessed on an ordinal scale, not verified by a standardized test. Self-ratings can be biased by self-concept or recent experiences and may also correlate with access to English-language media and instruction. Future studies should complement self-ratings with objective proficiency measures, such as teacher assessments.

The questionnaire relied entirely on self-reported perceptions, which may be influenced by social bias or limited self-awareness. Students may over- or underestimate their digital and AI competencies, particularly in areas such as ethics or critical evaluation. Objective performance-based assessments could complement these findings in future studies. Longitudinal designs would further track development and change over time, especially given the fast pace of technological advancement.

AI-use frequency or type-of-use measures (e.g., academic vs. recreational; generation vs. evaluation) were not collected; however, these data clarify the link between lifelong learning and confidence and personalisation.

5.3. Implications

The findings of this study support several practical and pedagogical implications for educators, school leaders, and policy-makers seeking to foster students' digital and AI literacy in meaningful, equitable, and future-oriented ways. Given the uneven levels of AI ethics awareness and responsible technology use, especially across different school types, curricula should more explicitly incorporate ethical reasoning, privacy, and digital responsibility. Both frameworks highlight the need for nurturing socio-emotional and ethical competencies alongside technical skills. These should not remain peripheral topics but be embedded across subjects and age groups, with authentic, real-world scenarios involving AI use.

The strong link between English proficiency and literacy dimensions, such as digital empathy and communication, highlights an opportunity to support language learning through well-selected AI applications. Teachers should implement the use of AI applications to develop learners' reflective and metacognitive skills and extend their digital agency. As students' ability to experiment with AI tools and navigate digital challenges emerged as important predictors of literacy levels, schools and teachers should promote learner autonomy and encourage exploration beyond the classroom.

Specifically for an ELT context, the findings provide practical implications. To support the results for RQ1 in language teaching, teachers can embed "evaluate-then-use" routines: e.g., students ask

an AI for a summary, highlight hallucinations, revise the prompt, and add citations in their own words. Short "source-triangulation" activities (two credible sources + one suspicious post) can precede writing tasks; paraphrase/citation checklists can be included in writing rubrics to keep ethics alive in everyday language work. For RQ2, ELT tasks that focus on viewpoint and audience, e.g., replying to a forum post with evidence, or converting a fact-checked outline into a persuasive email, can turn evaluation into discussion practice. Teachers can differentiate supports (credibility checklists, model language) to close gaps while advancing interactional competence. To apply the results for RQ3 in the ELT classrooms, shared AI use policies in writing assignments, common rubrics that include 'critical use of tools' and 'source integrity,' and cross-curricular projects where learners produce multimodal texts with documented prompt trails and reflection paragraphs could be taken into consideration. As a support for RQ4, ELT teachers can apply AI-mediated role-plays (e.g., customer support chats) to rehearse tone, register, and empathy; lower-proficiency learners can use sentence frames and tone aids, while advanced learners adapt style to audience. Reflection prompts ("Why did you choose this tone?" "How might it be received?") link pragmatic choice to ethical awareness.

Future research should consider an international expansion of this study to strengthen the findings. Furthermore, the incorporation of longitudinal or qualitative methodologies could enhance the generalisability of the results.

6. Conclusion

This study set out to explore Hungarian secondary school students' digital and AI literacy through two multidimensional frameworks: the Digital Intelligence Framework (DQ Institute, 2019) and the Digital Competency Framework (Conseil supérieur de l'éducation, 2019). By examining students' awareness of AI ethics, their critical engagement with digital sources, and the role of variables such as school type and self-assessed language proficiency, the research offers timely insights into the developing landscape of technology-enhanced education.

The results reveal that many students demonstrate emerging competencies in digital responsibility and information verification. Public school students reported higher awareness of ethical AI use, while higher English proficiency correlated with stronger communication and empathy skills in digital environments. These findings underscore the importance of contextual, inclusive approaches to literacy development that exceed mere technical fluency and address ethical, cognitive, and communicative dimensions.

The study's findings align with and extend prior research calling for holistic digital education frameworks and demonstrates that applying such models can clarify not only what students know, but how they think, act, and make decisions in digital contexts (Hammoda & Foli, 2024; Marín & Castañeda, 2023; Tinmaz et al., 2022). Unlike educator-focused frameworks such as DigCompEdu (Redecker, 2017), which prioritises teacher competencies, or the UNESCO AI Competency Frameworks (2024a; 2024b), which offer broad policy-oriented guidelines, the Digital Intelligence Framework (DQ Institute, 2019) and the Digital Competency Framework (Conseil supérieur de l'éducation, 2019) provide student-centred, adaptable models that effectively capture the complexities of secondary students' digital and AI literacy. Similarly, the Common Framework of Reference for Intercultural Digital Literacies (CFRIDiL) (Sindoni et al., 2021) and the Global Framework for Educational Competence in the Digital Age (Sáez et al., 2020) emphasize multimodal and intercultural dimensions but are less tailored to

secondary school contexts. By applying the chosen frameworks, this study bridges these gaps, offering a practical, learner-focused approach that integrates language learning with digital and AI literacy, addressing the contextual nuances of Hungarian secondary education.

Hungarian research further contextualizes these findings. Dringó-Horváth et al. (2025) highlight the interplay between digital competence and AI literacy among university teachers, noting demographic influences like gender and discipline, yet their focus on higher education limits direct applicability to secondary students. Folmeg et al. (2024) explore Hungarian higher education students' use of ChatGPT, emphasizing the need for critical evaluation and ethical integration in curricula, but their study's scope excludes younger learners. Szabó et al. (2023) provide insights into Hungarian youth's digital education experiences during the COVID-19 pandemic, exposing infrastructural and social inequalities that correspond to this study's findings on school-type differences.

The study also highlights the value of integrating AI literacy explicitly into the secondary school curriculum, not just as a set of skills, but as a mindset. Importantly, the implications extend directly to language learning. As AI tools increasingly support EFL instruction, students must be taught not only to use these tools, but to evaluate, question, and adapt them responsibly. As Folmeg et al. (2024) note, students' use of AI for tasks like translation and text creation requires critical evaluation to address issues like generic or outdated outputs. Language educators have an important role in equipping learners with the ability to express themselves clearly, ethically, and critically in digital environments. This calls for integrating digital and AI literacy skills into language curricula to prepare students for real-world communication that is both linguistically accurate and digitally responsible.

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