MASTERARBEIT | MASTER'S THESIS

Titel | Title

Growing Up Online: Digital Maturity in Adolescence and Its Relation to Self-Regulation

verfasst von | submitted by

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angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien | Vienna, 2026

Studienkennzahl lt. Studienblatt | Degree programme code as it appears on the student record sheet:	UA 066 840
Studienrichtung lt. Studienblatt | Degree programme as it appears on the student record sheet:	Masterstudium Psychologie
Betreut von | Supervisor:	Univ.-Prof. Dipl.-Psych. Dr. Arnd Florack

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Acknowledgement

Ich möchte mich herzlich bei Professor Florack für die Betreuung meiner Masterarbeit bedanken.

De főleg köszönöm nektek, akik elviseltétetek és elszenvedtétek az egyetemi idegbajaimat. (Véletlenül se olvassátok el.)

Abstract

Digitale Technologien sind ein zentraler Bestandteil des Lebens von Jugendlichen. Dennoch ist bisher noch nicht ausreichend verstanden, welche Fähigkeiten einen verantwortungsvollen und selbstbestimmten Umgang mit digitalen Technologien unterstützen. Diese Fähigkeiten lassen sich mit dem Konzept der digitalen Reife beschreiben, das die Fähigkeit von Jugendlichen bezeichnet, digitale Technologien kompetent, autonom und sozial verantwortungsvoll zu nutzen. Diese Masterarbeit untersuchte digitale Reife im Jugendalter und ihren Zusammenhang mit Alter, Selbstregulation und nationalem Kontext. Dafür wurden in einem querschnittlichen Multi-Kohorten-Design Umfragedaten von 3.831 Jugendlichen im Alter von 12 bis 18 Jahren aus sieben europäischen Ländern analysiert. Digitale Reife wurde mit dem Digital Maturity Inventory erfasst. Zur Analyse wurden Mixed-Effects-Regressionsmodelle sowie Gruppenvergleiche auf Länderebene durchgeführt. Digitale Reife war positiv mit dem Alter verbunden, was darauf hinweist, dass ältere Jugendliche eine höhere digitale Reife berichteten als jüngere Jugendliche. Selbstregulation war ein starker positiver Prädiktor digitaler Reife, und Alter blieb auch nach Kontrolle von Selbstregulation signifikant. Zudem zeigten sich signifikante Länderunterschiede in digitaler Reife. Auf Dimensionsebene fanden sich altersbezogene Unterschiede vor allem bei digitaler Literacy, Autonomie in digitalen Kontexten, digitaler Bürgerschaft, respektvollem Verhalten gegenüber anderen online, autonomer Entscheidung zur Nutzung mobiler Geräte und Unterstützungssuche. Diese Ergebnisse deuten darauf hin, dass digitale Reife mit allgemeiner Selbstregulationsfähigkeit zusammenhängt, zugleich aber auch bereichsspezifische Kompetenzen umfasst, die sich über das Jugendalter und über Kontexte hinweg unterscheiden. Insgesamt zeigt die Studie, dass das digitale Engagement von Jugendlichen breiter verstanden werden sollte als nur im Sinne technischer digitaler Literacy.

Schlagwörter: digitale Reife, Jugendalter, Selbstregulation, digitale Kompetenz, länderübergreifende Unterschiede, digitales Verhalten

Abstract

Digital technologies are a central part of adolescent life, yet the capacities that support responsible and self-determined digital engagement remain insufficiently understood. These capacities can be described through the concept of digital maturity, which refers to adolescents' ability to use digital technologies in a competent, autonomous, and socially responsible way. This thesis examined digital maturity in adolescence and its relation to age, self-regulation, and national context. Using a cross-sectional multi-cohort design, survey data from 3,831 adolescents aged 12 to 18 years from seven European countries were analyzed. Measured with the Digital Maturity Inventory mixed-effects regression models and country-level group comparisons were conducted. Digital maturity was positively associated with age, indicating that older adolescents reported higher digital maturity than younger adolescents. Self-regulation was a strong positive predictor of digital maturity, and age remained significant after controlling for self-regulation. Significant country differences in digital maturity were also observed. At the dimension level, age-related differences were found mainly for digital literacy, autonomy within digital contexts, digital citizenship, respect toward others online, autonomous choice to use mobile devices, and support seeking. These findings suggest that digital maturity is related to general self-regulatory capacity but also reflects domain-specific competencies that vary across adolescence and across contexts. Overall, the study highlights the importance of understanding adolescents' digital engagement in terms broader than technical digital literacy alone.

Keywords: digital maturity, adolescence, self-regulation, digital competence, cross-national differences, digital behavior

Introduction

Between 2017/18 and 2021/22, the share of Austrian adolescents spending five or more hours daily on their smartphones rose from 23% to 38%, a striking shift in just four years (Felder-Puig & Teufl, 2025). In 2022, as a response, the Austrian government launched the *Digitale Kompetenzoffensive*, a national strategy to strengthen digital literacy and help citizens engage safely and responsibly with digital technologies (Bundesministerium für Wirtschaft, Energie und Tourismus, 2022). That same year, Digitale Grundbildung became a compulsory subject in lower secondary schools, a concrete acknowledgment that navigating digital environments had become a central developmental challenge for young people, not just a skill to be picked up along the way (Hörmann et al., 2023).

What these developments point to, taken together, is a challenge that goes beyond any single country's policy agenda: digital technologies have become a fundamental part of how young people grow up, yet the psychological capacities required to navigate them remain poorly understood. This matters because adolescence is already a demanding period in its own right, characterized by rapid biological maturation, expanding autonomy, and fundamentally shifting social relationships (Klimstra et al., 2018; Van den Akker et al., 2021). Today, these transitions play out in conditions of near-constant digital connectivity. Approximately 98% of 15-year-olds across OECD countries own an internet-enabled smartphone, and more than one third of adolescents across 44 countries report being in continuous online contact with others throughout the day (Boniel-Nissim et al., 2024; OECD, 2025). Cohort comparisons suggest that adolescents' digital immersion has intensified over time, with children in a 2017/18 cohort spending significantly more time on digital devices and social media than those born a decade earlier (Bohnert & Gracia, 2021). For today's adolescents, digital environments are not something added onto development from the outside. They are one of the central developmental contexts.

The implications of this digital immersion are, however, very ambivalent. On one hand, digital platforms offer genuine opportunities for learning, creativity, social connection, and civic participation (Koch et al., 2025; OECD, 2025). On the other hand, they expose adolescents to a range of risks including cyberbullying, harmful content, misinformation, harmful online challenges, appearance-related pressure, unauthorized sharing of sensitive material, privacy violations, and compulsive patterns of use (Kasturiratna et al., 2025; Lahti et al., 2024; OECD, 2025; Pazdur et al., 2025), and the population health data reflect this tension clearly. A meta-analysis of 133 independent samples comprising over 244,000 participants found moderate associations between problematic social media use and depression and loneliness, alongside smaller negative associations with life satisfaction and self-esteem (Huang, 2022). National Austrian data tell a similar story, linking high daily smartphone use to recurrent somatic complaints including headaches, visual problems, and sleep difficulties, and severe problematic social media use to depressive mood, loneliness, and negative body image (Felder-Puig & Teufl, 2025). Across 44 countries, the prevalence of problematic social media use among adolescents rose from 7% in 2017/18 to 11% in 2021/22, with girls and younger adolescents disproportionately affected (Boniel-Nissim et al., 2024). Particularly notable is the evidence that these effects are not static: The negative impact of high screen time on socioemotional well-being appears to be stronger in more recent cohorts than in earlier generations, even after controlling for socioeconomic status and gender (Bohnert & Gracia, 2021). This makes adolescents' digital engagement an important developmental issue. However, screen time alone does not show whether adolescents use digital technologies in responsible, autonomous, or risky ways. A recent meta-analysis supports this point: Total screen time was only weakly related to self-regulation, whereas problematic digital engagement was much more strongly associated with lower self-regulation (Howard et al., 2025).

The present thesis therefore starts from the assumption that adolescent digital development cannot be understood by looking only at time spent online. What matters is also how adolescents engage with digital technologies and which capacities they bring to this engagement. Digital maturity is relevant here because it captures these capacities in a broader way. It includes digital literacy, but also risk awareness, autonomous decision-making, emotion and impulse regulation, support seeking, and respectful online interaction (Laaber et al., 2023). What remains less clear is how digital maturity differs across adolescence and whether it mainly reflects general self-regulation or a more specific competence for navigating digital environments. The present study addresses this question by examining digital maturity among adolescents aged 12 to 18 and investigating its relation to age, self-regulation, and national context. The following theoretical background first explains why screen time alone is insufficient for understanding adolescents' digital engagement, then introduces digital maturity as a broader developmental construct, and finally discusses the role of self-regulation and national context.

Theoretical Background

Self-Regulation and the Quality of Digital Engagement

Much of the previous research on adolescent digital use has focused on screen time as a primary measure. Although this approach shows how much time adolescents spend with digital technologies, it does not explain how they manage their digital engagement. This distinction is central to the present thesis, which focuses on digital maturity rather than digital use alone. Digital maturity refers to adolescents' capacity to engage with digital technologies in a competent, responsible, and self-determined way. Self-regulation is relevant to this question because it may help explain why some adolescents can manage digital challenges more successfully than others. Evidence supports the need for this broader perspective. A meta-analysis of 183 studies with more than 234,000 children and adolescents found that total screen time was only weakly related to self-regulation, with associations ranging from r = -.04 for computer use to r = -.15 for social media use. In contrast, lower self-regulation was more strongly associated with problematic mobile phone use (r = -.41), problematic gaming (r = -.28), and risky online behaviors such as communicating with strangers and sexting (Howard et al., 2025). Longitudinal evidence further shows that self-control and problematic smartphone use were negatively and bidirectionally related across three annual measurement points in a sample of 2,131 adolescents (Zhao et al., 2024). Together, these findings suggest that adolescents' digital behavior cannot be understood by screen time alone. Instead, it is important to examine the regulatory capacities that support more controlled, autonomous, and responsible digital engagement. This makes self-regulation an important starting point for understanding digital maturity.

Longitudinal research suggests that self-regulation is especially relevant for understanding problematic and impairing forms of adolescents' digital engagement. Over the course of adolescence, self-control tends to decline while perceived technological impairment concurrently increases, and these trajectories track each other closely: Adolescents who experience steeper drops in self-control also tend to show greater increases in technology-related problems over time (Burnell et al., 2023). What is particularly telling is the distinction between short-term and long-term effects. Day-to-day fluctuations in self-control do not reliably predict immediate increases in technology use, but adolescents with chronically lower trait self-control spend progressively more time in entertainment-based digital activities as development unfolds (Burnell et al., 2023). The risk, in other words, is not situational but dispositional.

Beyond stable differences in self-control, longitudinal research suggests that self-regulation and problematic digital engagement may influence each other over time. In a three-year study using parallel latent growth modeling, adolescents with higher initial self-regulation showed lower initial levels of problematic smartphone use and a slower increase in problematic use, whereas adolescents with lower initial self-regulation showed a stronger increase in problematic smartphone dependency (Xiao et al., 2025). Evidence also suggests that digital engagement may affect later regulatory functioning: Among high-risk adolescents, greater daily digital technology use predicted poorer self-regulation and more conduct problem symptoms 18 months later (George et al., 2018). These findings do not show that time online is irrelevant. Rather, they suggest that self-regulation is closely linked to whether digital engagement becomes problematic or difficult to control.

The distinction between the quantity and quality of digital engagement also matters for how digital competence is conceptualized. Traditional approaches often define digital competence in terms of digital literacy, such as the ability to use digital tools, navigate digital content, and evaluate online information. This understanding is reflected in frameworks such as the EU's DigComp and in large-scale assessments such as the International Computer and Information Literacy Study (Fraillon, 2025; Vuorikari et al., 2022). Digital literacy is an important foundation, and recent findings show that many adolescents still need support in developing these skills: In the most recent international assessment, nearly half of students across participating countries scored below baseline proficiency, and achievement declined between 2013 and 2023 in most countries with comparable data (Fraillon, 2025). These findings underline the importance of digital literacy, but they also leave open how such skills relate to the broader quality of adolescents' digital engagement.

However, digital literacy alone does not explain why some adolescents benefit from digital environments while others struggle in them. When digital skills are broken down by type, purely technical skills turn out to be associated with mixed or even negative outcomes, partly because they enable access to a broader range of both opportunities and risks

(Livingstone et al., 2023). Adolescents with stronger digital skills engage in more online activities, but they also encounter more risks, a consistent tradeoff that holds across studies and national contexts (Livingstone et al., 2023; Rodríguez-de-Dios et al., 2018). Knowing how to use technology, it seems, is not the same as knowing how to use it well. What the evidence shows instead are higher-order psychosocial capacities: impulse control, the regulation of negative emotions, and the ability to engage with digital environments in a self-determined rather than reactive way (Howard et al., 2025; Laaber et al., 2023). These competencies are not fully captured by traditional literacy-oriented frameworks, which focus primarily on knowledge, skills, and attitudes related to information use, communication, safety, and problem solving (Vuorikari et al., 2022). This may help explain why digital skills alone do not necessarily translate into better outcomes, as stronger digital skills can increase both online opportunities and exposure to online risks (Livingstone et al., 2023; Rodríguez-de-Dios et al., 2018). Addressing this gap requires a broader conceptualization of digital competence, one that integrates technical skills with the psychological capacities necessary for responsible and self-determined engagement (Arenas & Yazdi, 2022; Laaber et al., 2023).

Digital Maturity: A Comprehensive Developmental Competence

The construct of *digital maturity* was developed precisely to address these limitations of purely technical or time-based approaches to digital engagement. Grounded in humanistic frameworks of psychosocial maturation and self-determination theory, digital maturity is defined as the self-determined use of digital technologies in ways that promote individual psychological growth and social functioning while mitigating digital risks (Laaber et al., 2023).

Rather than reducing digital competence to technical skill or information literacy, digital maturity encompasses a wide range of psychosocial capacities, operationalized across ten empirically validated dimensions: autonomous choice to use mobile devices, autonomy within digital contexts, digital literacy, individual growth in digital contexts, digital risk awareness, regulation of negative emotions in digital contexts, regulation of impulses in digital contexts, support-seeking regarding digital problems, respect towards others in digital contexts, and digital citizenship (Laaber et al., 2023).

Qualitative research using grounded theory has identified a closely overlapping set of functional indicators, including perceived benefits and risks, managing tensions between engagement and harm, regulation of emotional responses, and digital civic behavior, as core elements of digital maturity (Arenas & Yazdi, 2022). Furthermore, quantitative socio-technical models have successfully utilized this conceptualization to cluster and predict youth digital behavior profiles (Siddiqui & Valogianni, 2022), providing converging evidence for the validity of this multidimensional framework. Validation studies confirm that the Digital Maturity Inventory (DIMI) predicts incremental variance in problematic mobile device use above and beyond age, amount of use, and broad personality traits such as conscientiousness, agreeableness, and negative emotionality (Laaber et al., 2023), establishing that digital maturity captures domain-specific competencies that cannot be reduced to general dispositional tendencies. This distinction is important because self-regulation may explain adolescents' general capacity to control impulses and emotions, whereas digital maturity captures whether these capacities are translated into competent, responsible, and context-sensitive behavior in digital environments.

The predictive reach of digital maturity extends well beyond device misuse. Higher digital maturity is positively associated with life satisfaction, positive affect, and psychological richness, whereas lower digital maturity is linked to negative affect and psychological distress (Laaber et al., 2024). These associations are mediated by the satisfaction or frustration of basic psychological needs for autonomy, competence, and relatedness in digital contexts (Laaber et al., 2024). Even when controlling for self-regulation, socioeconomic status, age, and gender, digital maturity continues to account for unique variance in these well-being outcomes, demonstrating its incremental explanatory value (Laaber et al., 2024).

Digital maturity is relevant not only because it relates to lower problematic technology use, but also because it is linked to more adaptive forms of online social engagement. Digitally mature adolescents are more likely to interact online with real-life friends rather than virtual-only contacts and to pursue compassionate rather than self-image goals in their interactions. These patterns are associated with stronger subjective social connectedness and lower loneliness, with longitudinal evidence supporting this association across two European countries (Koch et al., 2025). At the same time, network analyses of the DIMI show why self-regulation is central to the construct: impulse regulation and support-seeking regarding digital problems are among the most central nodes within the digital maturity network (Hofmans et al., 2024). Together, these findings suggest that digital maturity captures both positive social uses of digital media and the regulatory capacities that may support them.

On the antecedent side, digital maturity is shaped by the social environment in which development unfolds. Socioeconomic status relates positively to adolescents' digital maturity, but this association is fully mediated by active parental mediation: Parents with higher socioeconomic status engage more frequently in instructive, discussion-based guidance about digital risks and opportunities, and this guidance in turn fosters more autonomous and self-determined device use in their children (Koch et al., 2024). Restrictive mediation, by contrast, does not contribute to digital maturity development and may even hinder it by reducing adolescents' opportunities to practice navigating digital risks independently (Koch et al., 2024; Rodriguez-de-Dios et al., 2018).

Taken together, these findings suggest that digital maturity can be understood as a competence that is shaped by both individual capacities and contextual experiences. Existing research already shows that digital maturity is related to problematic device use, well-being, social connectedness, parental mediation, and socioeconomic context. This suggests that it is not simply a fixed disposition, but may develop through adolescents' repeated interactions with digital environments and the guidance, opportunities, and expectations they encounter. This interpretation is consistent with the social investment perspective, which argues that personality-related characteristics are shaped not only by stable dispositions or genetic influences, but also by social roles, experiences, and environmental contexts (Roberts et al., 2005). This model is useful for digital maturity because it treats development as an interaction between individual capacities and repeated experiences in specific social contexts. Applied to adolescents' digital lives, this suggests that online engagement may be influenced by several external factors and broader expectations around technology use. This view also aligns with neo-ecological theory, which understands digital environments as virtual developmental contexts embedded in broader cultural, educational, regulatory, and socioeconomic conditions (Navarro & Tudge, 2023). However, it remains unclear how digital maturity differs across adolescence and whether these differences mainly reflect general self-regulatory development. The present thesis addresses these questions by examining digital maturity in relation to age, self-regulation, and national context.

Self-Regulation as a Developmental Foundation

Self-regulation is important for understanding digital maturity, but it cannot be treated as the same construct. Digital maturity includes capacities related to healthy digital engagement that are connected to self-regulation but extend beyond it. (Laaber et al., 2023). Self-regulation therefore provides a general developmental foundation for digital maturity, while digital maturity captures how these capacities are applied in digital contexts (Laaber et al., 2023). Self-regulation refers to the ability to monitor and regulate thoughts, emotions, and behavior in the service of personally meaningful goals (Wesarg-Menzel et al., 2023). It includes related abilities such as inhibitory control, working memory, cognitive flexibility, and emotion regulation, which can develop at different rates during childhood and adolescence (Wesarg-Menzel et al., 2023).

Self-regulation develops through both individual maturation and social experience. A meta-review of 136 articles distinguished between two developmental pathways: an ability pathway, which refers to the maturation of executive functions, and a goals-and-motivation pathway, which refers to the social contexts in which regulation is needed (Wesarg-Menzel et al., 2023). This distinction matters for digital maturity because adolescents may have the cognitive ability to regulate their behavior, but may not always use this ability in situations that are emotionally intense, socially rewarding, or difficult to disengage from (Wesarg-Menzel et al., 2023). During adolescence, peer feedback becomes especially important for motivation and behavior, which is relevant because many digital interactions are peer-oriented, immediate, and socially visible (Wesarg-Menzel et al., 2023).

Adolescence is a period in which self-regulation is still developing while sensitivity to rewards and social cues is high. Dual-systems accounts suggest that reward-related processes become especially responsive around puberty, whereas cognitive control develops more gradually into early adulthood (Casey et al., 2008; Somerville et al., 2010; Steinberg, 2007). This helps explain why some adolescents are especially sensitive to immediate rewards and social feedback (Somerville et al., 2010; Steinberg, 2007). In a study of 935 participants aged 10 to 30, sensation-seeking increased from late childhood into mid-adolescence before declining or stabilizing, whereas impulse control developed more gradually and linearly (Steinberg et al., 2008). However, this pattern does not apply equally to all adolescents. A longitudinal cohort study following 1,522 youths from age 11 to 20 found that the combination of high sensation-seeking and low self-regulation predicted delinquent behavior mainly in a specific subgroup of adolescents (Murray et al., 2021).

These developmental patterns are relevant for digital engagement because digital environments often place repeated demands on adolescents' self-regulation. Social media, games, and messaging platforms can involve immediate feedback, continuous online contact, and platform features that encourage repeated engagement (Boniel-Nissim et al., 2024; OECD, 2025). Adolescents therefore need to decide when to respond, when to stop, and how to manage emotional or social situations online. This does not mean that digital use is harmful in itself. Rather, it suggests that digital environments can make individual differences in self-regulation especially visible (Howard et al., 2025; OECD, 2025).

Studies also show that self-regulation is linked to how young people use digital technologies. In a study using objective smartphone data from 101 participants, heavier smartphone use was associated with steeper delay discounting and lower dispositional self-control, especially for social media and gaming applications (Schulz van Endert & Mohr, 2020). Further evidence from a representative sample of 2,697 adolescents aged 11 to 15 showed that self-control, sense of control, and self-regulation of digital media use were related to risky digital media use, including excessive internet use and impulsive digital media use (Hrbackova et al., 2025). These findings show that self-regulation is not only a general developmental capacity, but also relevant for how young people respond to the specific demands of digital environments.

Self-regulation itself is not fixed during adolescence. Longitudinal evidence suggests that self-regulation continues to change during early adolescence, with improvements in some components and difficulties in others. In the ABCD study, cognitive self-regulation and expressive suppression increased slightly, whereas behavioral self-regulation decreased slightly; negative life events and parental mental health problems also predicted poorer later self-regulation (Reyentanz et al., 2025). This is relevant for the present thesis because digital maturity may partly reflect adolescents' developing self-regulatory capacities, but may also depend on the digital experiences, support, and contextual resources available to them (Koch et al., 2024; Laaber et al., 2023; Reyentanz et al., 2025).

Taken together, self-regulation is a key developmental foundation for understanding adolescents' digital engagement. Adolescents with stronger self-regulation may be better able to manage impulses, emotions, and social pressure in digital environments, whereas adolescents with weaker self-regulation may be more vulnerable to problematic or difficult-to-control forms of use (Howard et al., 2025; Hrbackova et al., 2025; Schulz van Endert & Mohr, 2020). However, digital maturity likely goes beyond general self-regulation because it also includes digital knowledge, risk awareness, support seeking, and socially responsible behavior online, and because previous research shows that digital maturity explains relevant outcomes even after controlling for self-regulation (Laaber et al., 2023; Laaber et al., 2024). The next section therefore examines more directly how self-regulation and digital maturity are related, and whether digital maturity can be understood as a broader, domain-specific competence.

The Relationship Between Self-Regulation and Digital Maturity

Given this evidence, self-regulation and digital maturity are clearly related, yet the nature of their relationship requires careful conceptual clarification. Several of the ten dimensions of the Digital Maturity Inventory (DIMI) draw directly on self-regulatory processes. Impulse regulation, regulation of negative emotions, and autonomous choice all involve the application of executive control in digitally specific contexts (Laaber et al., 2023).

Network analyses further identify impulse regulation as the most highly connected node within the digital maturity system, suggesting that self-regulatory capacity provides an important structural foundation for the broader construct (Hofmans et al., 2024).

Within the cybernetic personality framework, personality traits are understood as reflecting the functioning of goal-directed, self-regulating psychological systems, while characteristic adaptations represent their context-specific expressions (DeYoung, 2015). From this perspective, digital maturity can be interpreted as a context-specific adaptation of general self-regulatory tendencies to the affordances and demands of digital environments. This interpretation helps explain why the two constructs overlap conceptually while remaining empirically distinct.

Importantly, digital maturity cannot be reduced to domain-general self-regulation. Validation studies demonstrate that the DIMI predicts problematic device use above and beyond broad personality traits, age, and usage amount (Laaber et al., 2023), and explains unique variance in well-being outcomes even when self-regulation, socioeconomic status, age, and gender are explicitly controlled (Laaber et al., 2024). Moreover, several DIMI dimensions capture competencies that extend beyond general regulatory capacities. Digital literacy involves knowledge about how platforms function and how information quality can be evaluated. Digital risk awareness requires familiarity with context-specific threats such as privacy violations, cyberbullying, and algorithmic manipulation. Respectful online interaction depends on understanding the social norms that structure communication in digital environments.

Accordingly, digital maturity reflects not only the regulation of behavior but also the capacity for self-determined and context-aware engagement with technology (Hrbackova et al., 2025; Laaber et al., 2023). Qualitative research supports this interpretation by showing that adolescents themselves distinguish between simply knowing how to use technology and knowing how to use it well, an understanding that integrates regulatory capacities with specifically digital competencies (Arenas & Yazdi, 2022). Quantitative socio-technical models that classify youth digital behavior profiles similarly rely on this ability to assess and regulate context-specific technology use (Siddiqui & Valogianni, 2022).

Taken together, these findings suggest that the relationship between self-regulation and digital maturity is likely to be positive but partial. The constructs share common regulatory foundations, yet digital maturity also encompasses competencies that develop through learning, experience, and socialization in digital environments. Adolescence is characterized by substantial developmental changes in self-regulatory capacities and motivational processes (Steinberg, 2007; Wesarg-Menzel et al., 2023), and related psychological traits often follow systematic age-related trajectories across this period (Van den Akker et al., 2021), digital maturity may likewise change across adolescence.

Despite growing empirical interest in digital maturity, existing research has focused primarily on its conceptualization, measurement, and associations with outcomes such as well-being and patterns of technology use (Laaber et al., 2023; Laaber et al., 2024; Koch et al., 2025). Comparatively little attention has been devoted to examining how digital maturity itself develops across adolescence. As a result, it remains unclear whether digital maturity increases steadily with age, mirrors developmental patterns observed in self-regulation, or follows distinct developmental trajectories.

Developmental and Contextual Variation in Digital Maturity

Addressing the lack of research on how digital maturity develops during adolescence requires focusing specifically on the developmental window between ages 12 and 18. This period is particularly consequential because it captures the onset and peak of the neurobiological imbalance between reward sensitivity and cognitive control, substantial fluctuations in self-regulatory capacities, and a phase in which peer-oriented digital interaction becomes increasingly central to adolescents' social lives (Casey et al., 2008; Steinberg, 2007). Understanding how digital maturity varies across this developmental window therefore has direct implications for identifying when interventions designed to support adaptive digital engagement may be most effective.

There are strong theoretical reasons to expect digital maturity to be higher among older adolescents. Within the 12-to-18-year age span, older adolescents have accumulated greater experience navigating digital environments and may also have had more opportunities for formal and informal learning about digital literacy and online risks (OECD, 2025). Furthermore, adolescents' cognitive capacities for logical reasoning and risk evaluation approach adult levels by mid-adolescence (Steinberg, 2007). Some indirect empirical evidence is consistent with this expectation. In a cross-sectional sample of participants aged 9 to 43, older participants showed higher digital literacy and were less likely to seek support for digital problems, while the overall structure of digital maturity remained similar across age groups (Hofmans et al., 2024). Higher digital maturity is also associated with more socially meaningful forms of online engagement, such as pursuing compassionate goals and interacting with real-life friends rather than exclusively online contacts (Koch et al., 2025), a pattern that is broadly consistent with developmental processes of increasing commitment and identity formation during the transition to late adolescence and young adulthood (Kukkola et al., 2023). This expectation further corresponds with well-documented mean-level differences in the personality literature, specifically higher agreeableness, conscientiousness, and emotional stability in older cohorts, reflecting a broader progression toward greater self-regulation and social responsibility, commonly referred to as the maturity principle (Bleidorn, 2024; Bleidorn et al., 2013; Klimstra et al., 2018). Based on these theoretical and empirical considerations, Hypothesis 1 states that age is positively associated with digital maturity.

At the same time, developmental changes in digital maturity may not follow a strictly linear trajectory across the 12-to-18 age span. Developmental research documents an adolescent "maturity dip," in which traits associated with cooperativeness, impulse control, and conscientiousness temporarily decline during early to mid-adolescence before increasing again toward late adolescence (Van den Akker et al., 2021). This temporary disruption is thought to arise from the rapid physical and hormonal changes associated with puberty, which create a mismatch between rising environmental expectations and adolescents' still-developing psychological capacities (Van den Akker et al., 2021). Evidence for age-related changes in personality traits during adolescence has also been observed across large national samples (Allik et al., 2004). Applying this framework to digital maturity suggests that dimensions most closely tied to impulse and emotion regulation, which constitute central nodes within the digital maturity network (Hofmans et al., 2024), may show temporary plateaus or slower growth in early adolescence before increasing more strongly in later adolescence. Based on these findings, Hypothesis 2 states that the age-related trajectory of digital maturity will be non-linear across the 12-to-18 age span, reflecting a relative plateau or dip in early-to-mid adolescence.

This potential non-linearity raises an additional question regarding the relationship between age-related changes in digital maturity and developmental changes in self-regulation. If digital maturity merely reflects general self-regulatory development, age-related differences in the construct should diminish once self-regulation is statistically controlled. However, if digital maturity represents a context-specific competence, one that accumulates through digital experience and the acquisition of domain-specific skills, it should continue to show meaningful age differences even after accounting for individual differences in self-regulation. Existing evidence supports this latter interpretation: digital maturity explains unique variance in well-being and behavioral outcomes beyond both broad personality traits and explicitly controlled self-regulation (Laaber et al., 2023, 2024). Research in personality development suggests that developmental change is not fully reducible to broad mean-level trait trends and may vary across contexts and life transitions (Bleidorn, 2024; de Moor et al., 2023). Taken together, these considerations suggest that digital maturity may overlap with self-regulation, but should not be reduced to it. Therefore, Hypothesis 3 states that self-regulation is positively associated with digital maturity. Hypothesis 4 further states that age remains positively associated with digital maturity after controlling for self-regulation.

In addition to developmental processes within individuals, digital maturity may also vary across broader socio-cultural contexts. Cross-national research shows that adolescents' digital lives differ between countries in terms of online contact, problematic social media use, gaming, and digital literacy (Boniel-Nissim et al., 2024; Fraillon, 2025; OECD, 2025). These differences suggest that national context may shape not only how often young people use digital technologies, but also the skills, norms, and support structures that influence digital engagement. More directly, emerging research on digital maturity indicates that national context is associated with both the overall level of digital maturity and the relative importance of its underlying dimensions. Using data from five European countries and a machine-learning approach, national context was found to influence young people's digital maturity and the structural relationships among its components (Christensen et al., 2025). Dimensions related to digital risk awareness and individual growth appeared particularly sensitive to national context, whereas dimensions related to peer interaction were more stable across countries (Christensen et al., 2025).

The neo-ecological theoretical framework provides a useful lens for understanding these contextual influences. Extending classical bioecological theory to the digital age, virtual microsystems, understood as online environments that carry their own relational structures and symbolic features, have been conceptualized as legitimate developmental contexts embedded within broader macrosystemic conditions such as national digital culture and educational policy (Navarro & Tudge, 2023). Cross-cultural personality research similarly demonstrates that even broad developmental trends such as the maturity principle vary in their timing across societies depending on culture-specific social clocks and normative role transitions (Bleidorn et al., 2013). Accordingly, national differences in practices such as active parental mediation and digital citizenship education may help explain why average levels of digital maturity vary across countries (Christensen et al., 2025; Koch et al., 2024). Together, these perspectives highlight that digital maturity should be understood not only as a developmental outcome of individual psychological processes but also as a competence shaped by the socio-cultural environments in which adolescents' digital experiences are embedded. Based on this evidence, Hypothesis 5 states that the mean levels of digital maturity will differ across countries.

The Present Study

The present study examines digital maturity among adolescents aged 12 to 18 across multiple national contexts. It addresses the question of how digital maturity differs across adolescence and whether these differences are best understood as part of general self-regulatory development or as a more specific digital competence. To do so, the study compares age groups across early to late adolescence and tests whether digital maturity is associated with age in a linear or non-linear way.

The study further examines the role of self-regulation. Although previous research shows that digital maturity is related to self-regulation, it remains unclear whether age-related differences in digital maturity can be explained by general self-regulatory capacity.

Therefore, the analyses test whether self-regulation is positively associated with digital maturity and whether age remains associated with digital maturity after self-regulation is controlled. Finally, the study examines whether mean levels of digital maturity differ across countries.

To address these questions, the study uses a cross-sectional multi-cohort design across early to late adolescence and multiple national contexts. Building on the research reviewed above, the following hypotheses are proposed:

H1: Digital maturity will be positively associated with age, with older adolescents scoring higher than younger adolescents.

H2: The age-related trajectory of digital maturity will be non-linear across the 12-to-18 age span, reflecting a relative plateau or dip in early-to-mid adolescence.

H3: Self-regulation will be positively associated with digital maturity.

H4: The association between age and digital maturity will remain significant even after controlling for self-regulation.

H5: Mean levels of digital maturity will differ across countries.

Methods

Study Design and Procedure

The present study uses data from the DIGYMATEX project (https://digymatex.eu/), a large cross-national research initiative examining adolescents' development and behavior in digital environments. The project collected survey data from adolescents and their parents across several European countries in order to investigate digital competencies, developmental processes, and contextual factors associated with young people's engagement with digital technologies.

Data were collected between approximately April 2022 and February 2025 across participating countries. The surveys were administered online using the Qualtrics survey platform. Participants were recruited through professional online panel providers (e.g., Bilendi) operating in the respective countries. The recruitment strategy targeted adolescents and children between 9 and 18 years of age as well as one of their parents or legal guardians. The study included participants from Denmark, Germany, Austria, Greece, Spain, Slovakia, and United Kingdom. Survey instruments were translated into the respective national languages and adapted to ensure age-appropriate wording for adolescent respondents. Standardized translation procedures were applied to ensure conceptual equivalence of the measures across countries.

Participation involved responses from both a parent and their child. At the beginning of the survey, parents were provided with information about the study and were asked to provide informed consent for their own participation and for their child's participation. Parents first completed demographic questions and items concerning the family context. Subsequently, adolescents were asked to complete the questionnaire section. Parents were instructed to allow their child to complete this part of the questionnaire independently in order to facilitate honest responses.

After completing the survey, participants received a short debriefing explaining the aims of the research and how the collected data would contribute to the DIGYMATEX project.

The hypotheses and primary analytical strategy for this study were preregistered prior to conducting the analyses on the AsPredicted platform (AsPredicted.org). The preregistration specified the study hypotheses (H1–H5), key variables, and planned statistical analyses. The preregistration is publicly available at: https://aspredicted.org/9839cr.pdf. Analyses not included in the preregistration were conducted as exploratory analyses and are reported separately.

Ethics and Data Protection

Because participants were under the age of 18, ethical considerations were an important component of the study design. At the beginning of the online questionnaire, parents received detailed information about the purpose of the study, the procedures involved, and the handling of the collected data. Parents were asked to provide informed consent for both their own participation and their child's participation before the survey could proceed.

After parental consent had been obtained, adolescents were provided with a simplified explanation of the study and were asked to provide their own informed assent before answering the questionnaire. Participants were informed about the voluntary nature of participation, the procedures involved in the study, and their rights as participants.

At the end of the survey, participants received a debriefing with additional information about the study and contact details for the research team. Before final submission, parents were asked to provide final consent for the use of the data.

All data were collected and stored in accordance with applicable ethical guidelines and data protection regulations. Survey responses were processed anonymously, and no personally identifying information was linked to the questionnaire data.

Ethical approval for the study procedures was obtained from the Ethics Committee of the University of Vienna.

Participants

The analytic dataset consisted of 3,831 adolescents between 12 and 18 years of age (M = 14.41, SD = 1.74). Table 1 shows the age distribution in the sample.

Table 1
Age Distribution of the Sample

Age	*n*	%
12	682	17.8
13	645	16.8
14	729	19.0
15	652	17.0
16	573	15.0
17	408	10.7
18	142	3.7
Total	**3,831**	**100.0**

The gender distribution of the sample was relatively balanced. 48.7% of participants identified as female (N = 1,864) and 50.9% identified as male (N = 1,951). A small proportion of respondents identified as non-binary or another gender category (n = 6), preferred not to disclose their gender (n = 6), or self-described their gender identity (n = 4).

Participants were drawn from several European countries. The largest proportions of respondents were recruited from Germany (26.0%, n = 997) and Austria (25.4%, n = 972). Additional participants were recruited from Denmark (13.8%, n = 530), Slovakia (12.1%, n = 463), United Kingdom (8.9%, n = 340), Spain (7.0%, n = 269), and Greece (6.8%, n = 260).

Socioeconomic status scores ranged from 1 to 10 (M = 5.96, SD = 1.57). Table 2 shows the mean score by country.

Table 2
Descriptive Statistics for Socioeconomic Status by Country

Country	***n***	***M***	***SD***
Denmark	530	6.302	1.601
Germany	997	5.991	1.515
Austria	972	5.985	1.521
Greece	260	5.612	1.549
United Kingdom	340	5.791	1.777
Spain	269	5.877	1.460
Slovakia	463	5.795	1.609
Total	**3,831**	**5.96**	**1.57**

Data Cleaning and Exclusion Criteria

Prior to analysis, the dataset was screened to ensure that all cases met the predefined inclusion criteria. Because the study focused on adolescents, responses from participants who reported an age below 12 years were excluded from the analyses. These cases fell outside the targeted developmental age range and were therefore removed before conducting statistical analyses.

The survey included attention check items designed to evaluate whether respondents were completing the questionnaire attentively. However, attention check information was not available for all participants due to differences in questionnaire routing across survey waves and countries. Because a substantial portion of the dataset lacked attention check data, it was not possible to apply attention-check exclusions consistently across all cases. Excluding participants based on these items would therefore have introduced systematic bias. Consequently, attention check responses were not used as exclusion criteria, and all participants meeting the age inclusion criteria were retained in the analytic dataset.

Missing Data

Some variables in the dataset contained missing responses. In particular, the self-regulation measure was not administered to the entire sample. Valid self-regulation data were available for 834 participants, whereas the remaining cases were missing this variable. The missingness of the self-regulation data reflects differences in questionnaire versions across study waves rather than participant non-response. Analyses including self-regulation were therefore conducted using the subset of participants with available data for this measure, while analyses not requiring self-regulation used the full sample.

Measures

Digital Maturity

Adolescents' digital maturity was assessed using the Digital Maturity Inventory (DIMI) developed within the DIGYMATEX project (Laaber et al., 2023). The instrument measures adolescents' competencies and behaviors in digital environments and conceptualizes digital maturity as a multidimensional construct. Participants were instructed to consider their use of digital devices such as smartphones, tablets, or laptops when responding to the items. Example items include *"When using a mobile device, I learn new skills," "When using a mobile device, I choose the content I want to see,"* and *"When using a mobile device, I care about the feelings of others."* All items can be viewed in Appendix B (Table B1).

Most items were rated on a five-point Likert scale ranging from 1 (*"never"*) to 5 (*"always"*). Items from the digital literacy dimension were rated on a scale from 1 (*"not at all true of me"*) to 5 (*"very true of me"*).

Dimension scores were computed by averaging the items belonging to each dimension. Items from the dimensions autonomous choice to use mobile devices, regulation of negative emotions in digital contexts, and regulation of impulses in digital contexts were reverse-coded before dimension scores were computed, so that higher values consistently indicated higher digital maturity. Dimension scores were then calculated by averaging the items belonging to each dimension. Following the scoring procedure proposed by Laaber et al. (2023), the ten dimension scores were combined into an overall digital maturity composite using weights derived from expert evaluations conducted during the scale development process. Previous studies using the DIMI have reported satisfactory internal consistency across dimensions, with Cronbach's alpha values typically ranging between .72 and .91. In the present dataset, the overall reliability of the digital maturity scale was Cronbach's $\alpha = .84$. Internal consistencies for the ten dimensions are reported in Appendix B. Cronbach's alpha values ranged from $\alpha = .811$ to $\alpha = .883$ across dimensions, indicating good reliability.

Self-Regulation

Adolescents' self-regulation was measured using seven items derived from the Self-Regulation Scale (SRS) developed by Luszczynska et al. (2004). The scale assesses individuals' ability to maintain attentional control and regulate behavior while pursuing goals, which represents an important component of dispositional self-regulation. Participants responded to statements describing their capacity to sustain concentration and resume tasks after interruptions. Example items include *"I can concentrate on one activity for a long time, if necessary"* and *"After an interruption, I do not have difficulty returning to a task that requires concentration"*. All items are included in Appendix B (Table B2). Responses were recorded on a four-point Likert scale ranging from 1 ("not true") to 4 ("completely true"). The items were used to compute the overall self-regulation score. The scale demonstrated good internal consistency in the present dataset (Cronbach's $\alpha = .79$).

Socioeconomic Status

Socioeconomic status was assessed using a parent-reported subjective socioeconomic status ladder. Parents indicated the family's socioeconomic position on a scale from 1 to 10, with higher values indicating higher perceived socioeconomic status.

Analytical Strategy

To examine the relationships between age, self-regulation, and adolescents' digital maturity, a series of regression-based analyses were conducted. Participants were nested within countries, mixed-effects regression models were used in order to account for the hierarchical structure of the data. The general structure of the mixed-effects models can be expressed as: Digital maturity = $\beta_0 + \beta_1 X$ + (1 | Country), where X represents the predictor variable(s) included in the respective model and (1 | Country) denotes a random intercept for country.

As an initial step, a null model containing only a random intercept for country was estimated. This model allowed the proportion of variance in digital maturity attributable to differences between countries to be assessed and provided a basis for including country as a random effect in subsequent analyses.

The associations between age, self-regulation, and digital maturity were examined using regression models with digital maturity as the dependent variable. For analyses involving individual-level predictors, mixed-effects regression models were estimated with country included as a random intercept to account for the nested structure of participants within countries. Age and self-regulation were entered as continuous predictors depending on the respective hypothesis.

To examine whether age-related differences in digital maturity followed a non-linear pattern, age was additionally modeled using both a linear and a quadratic term. Before computing the quadratic term, age was mean-centered to reduce multicollinearity between the linear age predictor and its squared term and to facilitate interpretation of the regression coefficients (Aiken & West, 1991). Including both linear and quadratic age terms allows the model to capture possible curvilinear developmental patterns rather than assuming strictly linear change. This approach is consistent with previous developmental research examining non-linear age-related trajectories (Van Duijvenvoorde et al., 2016).

To examine whether mean levels of digital maturity differed across countries (H5), a linear regression analysis was conducted with country entered as a categorical predictor and digital maturity as the dependent variable. Denmark was specified as the reference category. This hypothesis focused on overall mean differences between specific country cohorts rather than individual-level prediction within a clustered hierarchical structure, this fixed-effects approach was utilized instead of a mixed-effects model. Prior to evaluating pairwise comparisons, the assumption of equal variances was assessed. The Levene's test indicated a violation of the homogeneity of variances assumption, Games-Howell post-hoc tests were employed to identify significant pairwise differences between country groups.

In addition to the regression analyses, descriptive statistics and Pearson correlation analyses were computed to examine associations between the main study variables. All statistical analyses were conducted using JASP (Version 0.95.4).

Results

The study employs a cross-sectional design, all age-related findings reflect differences between age cohorts rather than within-person developmental change. All mixed-effects models were estimated using restricted maximum likelihood (REML) with country included as a random intercept.

Descriptive Statistics

Table 3 presents descriptive statistics for the primary study variables. The mean age of the sample was 14.41 years (*SD* = 1.74). The overall digital maturity composite had a mean of 361.90 (*SD* = 41.01). In the self-regulation subsample, adolescents reported an average self-regulation score of 2.89 (*SD* = 0.51). Parent-reported subjective socioeconomic status averaged 5.96 (*SD* = 1.57). Gender was approximately equally distributed, with 48.7% female, 50.9% male, and 0.5% non-binary, self-described, or preferring not to say.

Table 6 summarizes the ten digital maturity dimensions. Mean scores were highest for autonomy within digital contexts ($M = 4.25$, $SD = 0.66$) and respect toward others online ($M = 4.00$, $SD = 0.74$), whereas digital citizenship showed the lowest mean ($M = 2.44$, $SD = 0.98$).

As shown in Table 4, age was positively associated with overall digital maturity, $r = .09$, $p < .001$, and with self-regulation, $r = .12$, $p < .001$, while showing a small negative association with subjective SES, $r = -.04$, $p = .014$. Self-regulation showed a substantially stronger positive association with overall digital maturity, $r = .52$, $p < .001$, indicating that adolescents with higher self-regulation tended to report higher digital maturity. Subjective SES was positively associated with overall digital maturity, $r = .10$, $p < .001$, but was not significantly associated with self-regulation, $r = .05$, $p = .171$. Correlations between age, self-regulation, and the individual DIMI dimensions are reported in Table 5; the remaining correlations among the DIMI dimensions are presented in Appendix A (Table A1).

Table 3
Descriptive Statistics of Main Study Variables

Variable	***n***	***M***	***SD***	**Min**	**Max**
Digital maturity	3,831	361.90	41.01	167.80	483.80
Age	3,831	14.41	1.74	12.00	18.00
Self-regulation	834	2.89	0.51	1.00	4.00

Variable	*n*	*M*	*SD*	Min	Max
Subjective SES	3,831	5.96	1.57	1.00	10.00

Table 4
Pearson Correlations Among the Primary Study Variables

Variable	1	2	3	4
1. Age	—			
2. Self-regulation	r = .120***	—		
3. Digital maturity	r = .088***	r = .516***	—	
4. Subjective SES	r = -.040*	r = .047	r = .103***	—

Note. Correlations involving self-regulation were based on the available self-regulation subsample, $n = 834$; all other correlations were based on $N = 3{,}831$. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 5
Pearson Correlations of Digital Maturity Dimensions With Age, Self-Regulation, and Subjective SES

Digital maturity dimension	Age	Self-regulation	Subjective SES
Autonomous choice to use mobile devices	-.056***	.227***	-.023
Autonomy within digital contexts	.108***	.235***	-.010
Digital literacy	.297***	.369***	.072***
Individual growth in digital contexts	.010	.178***	.094***
Digital risk awareness	.036*	.401***	.031
Regulation of negative emotions in digital contexts	-.013	.253***	.066***

Digital maturity dimension	Age	Self-regulation	Subjective SES
Regulation of impulses in digital contexts	.016	.201***	.012
Support-seeking regarding digital problems	-.140***	.204***	.050**
Respect towards others in digital contexts	.052**	.398***	.082***
Digital citizenship	.099***	.094**	.118***

Note. Values are Pearson zero-order correlations. Correlations involving self-regulation were based on the available self-regulation subsample, n = 834; all other correlations were based on N = 3,831. * p < .05, ** p < .01, *** p < .001.

Table 6

Descriptive Statistics of the Digital Maturity Dimensions

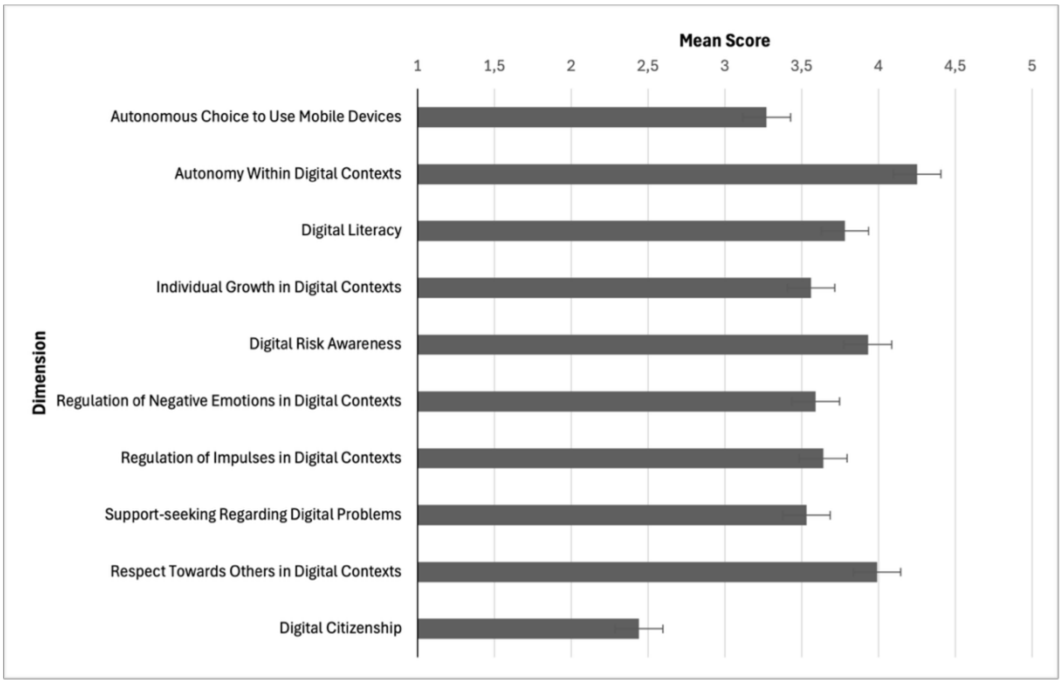
Dimension	*n*	*M*	*SD*
Autonomous Choice to Use Mobile Devices	3,800	3.27	0.95
Autonomy Within Digital Contexts	3,800	4.25	0.66
Digital Literacy	3,800	3.78	0.95
Individual Growth in Digital Contexts	3,800	3.56	0.70
Digital Risk Awareness	3,800	3.93	0.83
Regulation of Negative Emotions in Digital Contexts	3,800	3.59	0.89
Regulation of Impulses in Digital Contexts	3,800	3.64	0.89
Support-seeking Regarding	3,800	3.53	0.84

Dimension	*n*	*M*	*SD*
Digital Problems			
Respect Towards Others in Digital Contexts	3,800	4.00	0.74
Digital Citizenship	3,800	2.44	0.98

Note. Scores ranged from 1 to 5, with higher values indicating higher standing on the respective digital maturity dimension. Because 31 participants had missing data on one or more dimension scores, dimension-level descriptives are based on $n = 3{,}800$.

Figure 1

Mean Scores Across Digital Maturity Dimensions



Note. Bars represent mean scores for each digital maturity dimension. Error bars represent 95% confidence intervals. Dimension-level descriptives are based on $n = 3{,}800$ because 31 participants had missing data on one or more dimension scores.

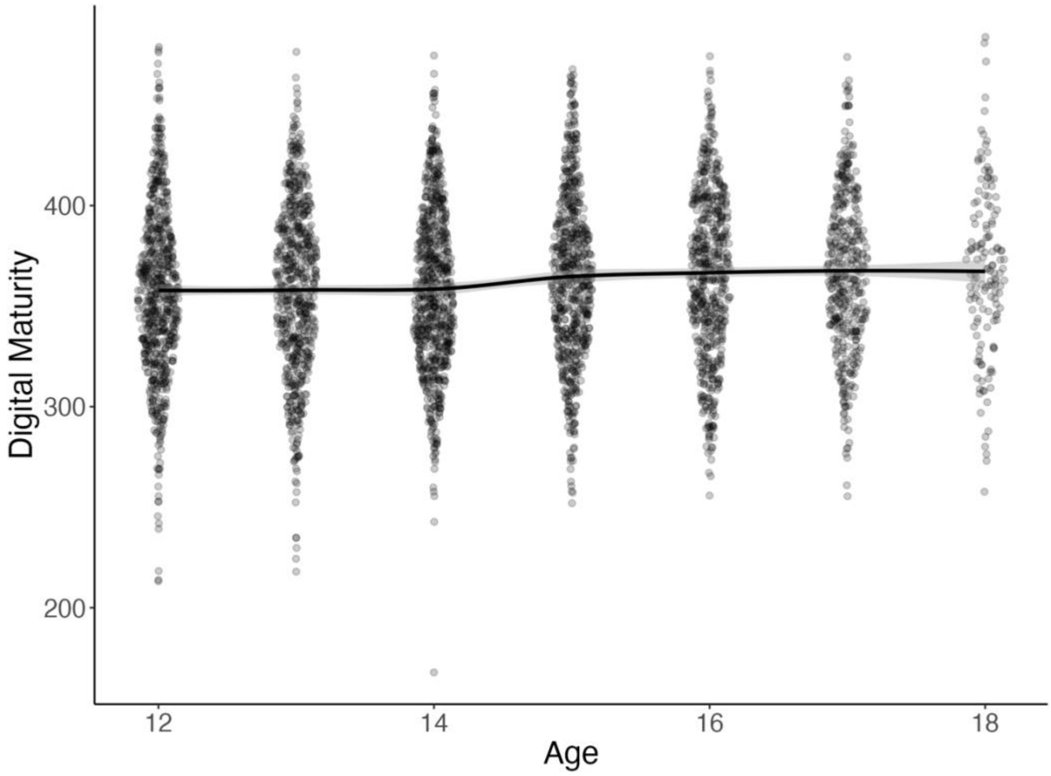
Hypothesis Tests

Before testing H1–H4, a null model including only a random intercept for country was estimated. The model indicated between-country variance in digital maturity (σ^2_country = 68.38, σ^2_residual = 1,634; ICC ≈ .04), supporting the inclusion of country as a random intercept in subsequent mixed-effects models.

The first hypothesis predicted that older adolescents would report higher digital maturity than younger adolescents. A linear mixed-effects model with age as the sole fixed predictor and country as a random intercept (Table 8, Model 1) supported this prediction. Age was a significant positive predictor, $B = 2.24$, $SE = 0.38$, $t(3826.21) = 5.96$, $p < .001$, such that each additional year of age was associated with approximately 2.24 points higher digital maturity in this cross-sectional sample. Given the scale range (100-500) and the standard deviation of the digital maturity score, this corresponds to approximately 0.055 standard deviations per year and should therefore be interpreted as a small age-related difference. The first hypothesis was supported, although the effect was modest.

Figure 2

Association Between Age and Digital Maturity



Note. Points represent individual participants. The solid line represents the fitted trend, and the shaded area represents the 95% confidence interval. The age–digital maturity association was based on $N = 3{,}831$.

The second hypothesis predicted a nonlinear age-related pattern, reflecting a relative plateau or dip in early-to-mid adolescence. To test this, a centered quadratic age term was added alongside the linear term (Table 8, Model 2). The linear age effect remained significant, $B = 2.25$, $SE = 0.39$, $t(3824.71) = 5.84$, $p < .001$, while the quadratic term was not significant, $B = -0.04$, $SE = 0.22$, $t(3826.74) = -0.17$, $p = .869$. This was not supported: the cross-sectional age gradient in digital maturity was linear across the 12-to-18 age range, with no evidence of the hypothesized nonlinearity.

To test whether age-related patterns differed across the individual DIMI dimensions, separate mixed-effects models were estimated for each dimension. In each model, the respective DIMI dimension was entered as the dependent variable, age was entered as a centered linear term and as a quadratic term, and country was included as a random intercept. Dimension-specific analyses indicated that age-related differences were not uniform across the digital maturity construct (Table 7). Significant positive linear age effects without evidence of quadratic curvature were found for autonomy within digital contexts, $B = .048$, $SE = .006$, $p < .001$, digital citizenship, $B = .053$, $SE = .009$, $p < .001$, and respect toward others in digital contexts, $B = .025$, $SE = .007$, $p < .001$. In contrast, support-seeking regarding digital problems showed a significant negative linear age effect, $B = -.072$, $SE = .008$, $p < .001$, indicating lower scores among older adolescents. Two dimensions showed both significant linear and quadratic age effects. Digital literacy showed a positive linear age effect, $B = .171$, $SE = .009$, $p < .001$, and a negative quadratic effect, $B = -.020$, $SE = .005$, $p < .001$, indicating that scores increased with age but that the increase became less steep at older ages. Autonomous choice to use mobile devices showed a negative linear age effect, $B = -.029$, $SE = .009$, $p = .001$, and a small positive quadratic effect, $B = .010$, $SE = .005$, $p = .046$. This suggests a weak curvilinear pattern, with predicted scores remaining relatively stable across age. Figure 3 displays the age-related patterns for the two dimensions showing curvilinear associations. No reliable age-related effects were found for individual growth in digital contexts, digital risk awareness, regulation of negative emotions in digital contexts, or regulation of impulses in digital contexts, as neither the linear nor the quadratic age terms reached significance for these dimensions.

Table 7

Age Associations With Digital Maturity Dimensions

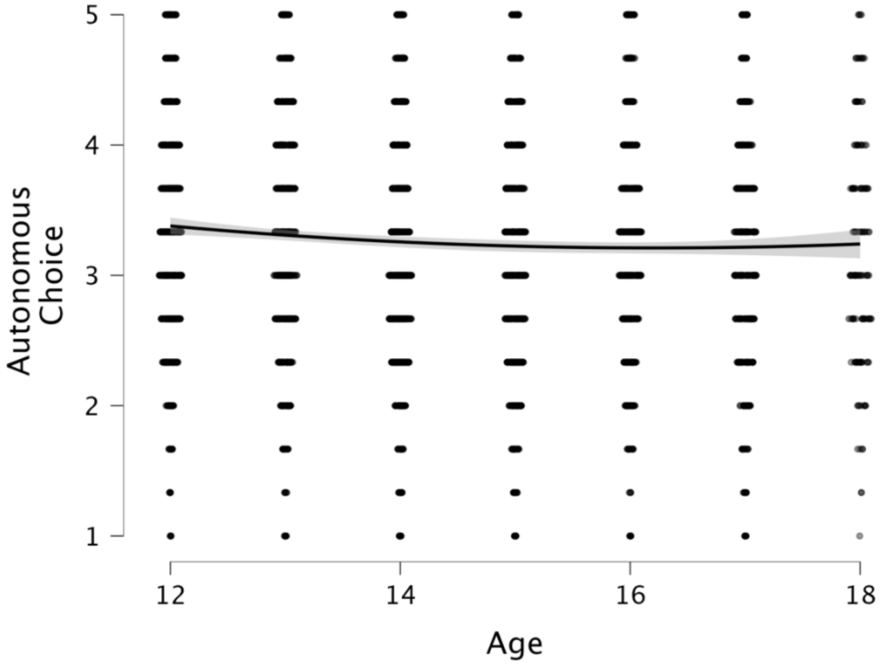
	Linear age effect			Quadratic age effect		
Dimension	***B***	***SE***	***p***	***B***	***SE***	***p***
Autonomous Choice to Use Mobile Devices	-.029	.009	.001	.010	.005	.046
Autonomy Within Digital Contexts	.048	.006	< .001	-.005	.004	.147
Digital Literacy	.171	.009	< .001	-.020	.005	< .001
Individual Growth in Digital Contexts	-.001	.007	.898	-.003	.004	.469
Digital Risk Awareness	.014	.008	.074	.008	.004	.067
Regulation of Negative Emotions in Digital Contexts	.000	.009	.960	-.006	.005	.188
Regulation of Impulses in Digital Contexts	.014	.008	.105	.005	.005	.300
Support-Seeking Regarding Digital Problems	-.072	.008	< .001	.006	.004	.147
Respect Toward Others in Digital Contexts	.025	.007	< .001	.001	.004	.769
Digital Citizenship	.053	.009	< .001	.003	.005	.545

Note. Positive *B* values indicate higher dimension scores with increasing age, whereas negative *B* values indicate lower dimension scores with increasing age. Dimension scores ranged from 1 to 5. Analyses were based on n = 3,800 (31 observations excluded because of missing dimension-level data).

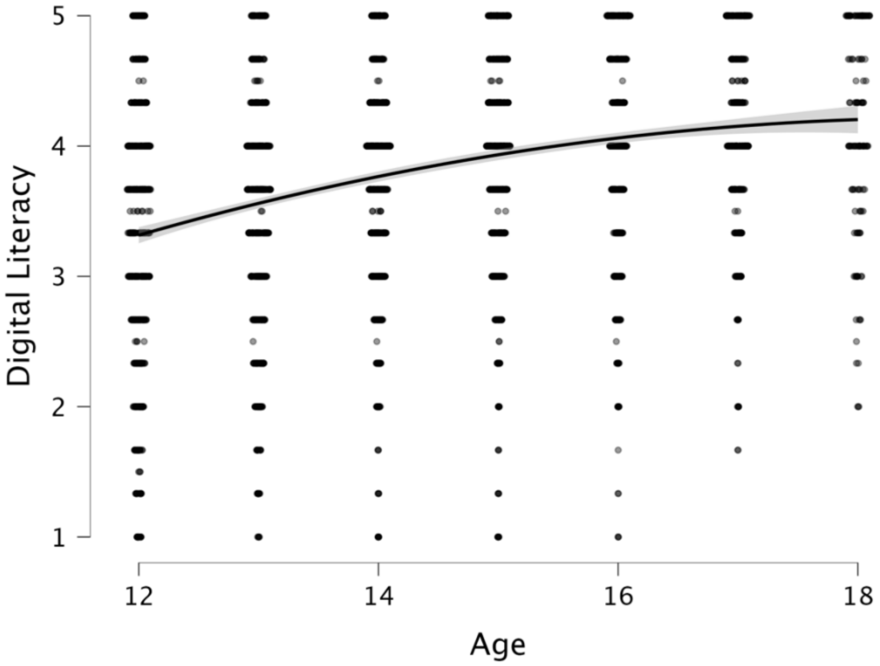
Figure 3

Curvilinear Age-Related Patterns in Two Digital Maturity Dimensions

Panel A: Autonomous Choice to Use Mobile Devices



Panel B: **Digital Literacy**

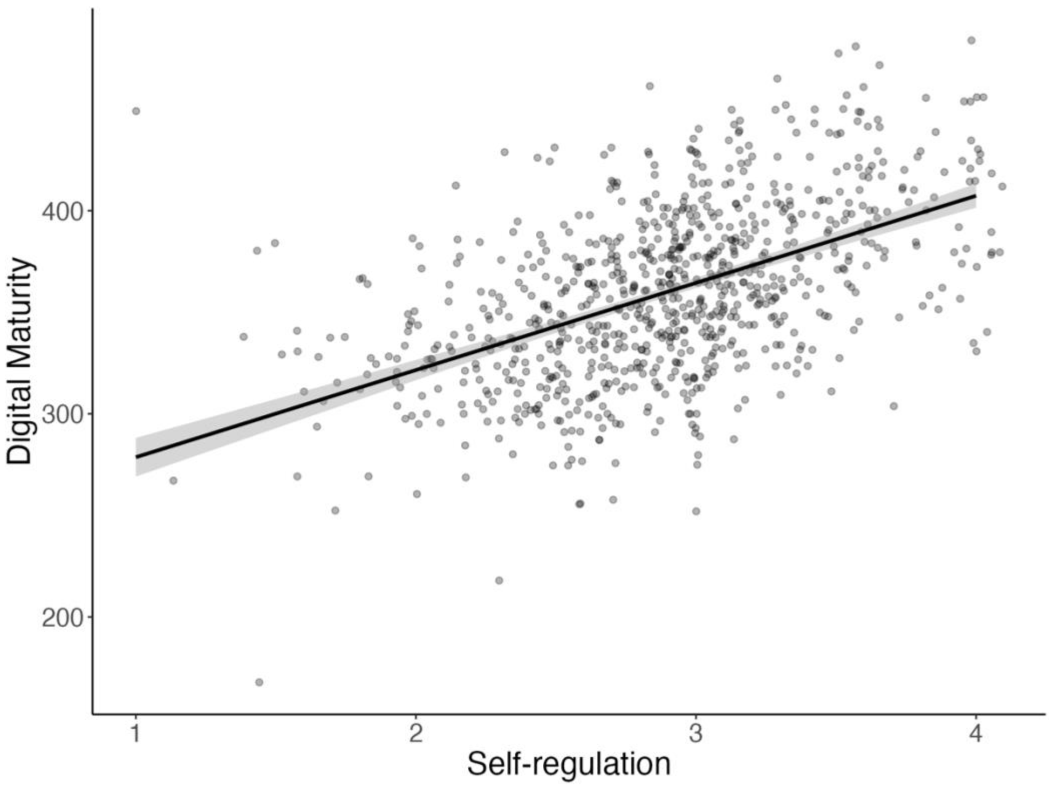


Note: Lines represent fitted quadratic age trends. Shaded areas represent 95% confidence intervals.

The third hypothesis predicted a positive association between self-regulation and digital maturity. In a model estimated in the self-regulation subsample (Table 8, Model 3; n = 834, 3 countries), self-regulation was a strong positive predictor, $B = 41.93$, $SE = 2.47$, $t(831.97) = 17.00$, $p < .001$. This was strongly supported. It should be noted, however, that the random-intercept structure for hypothesis 3 and 4 was based on only three country clusters. This limits the precision of the random-effects estimates, but does not affect the interpretation of the fixed-effect associations.

Figure 4

Association Between Self-Regulation and Digital Maturity



Note. Points represent individual participants. The solid line represents the fitted trend, and the shaded area represents the 95% confidence interval. This analysis was based on the self-regulation subsample (n = 834).

The fourth hypothesis predicted that age would remain a significant predictor of digital maturity even after controlling for self-regulation. In the combined model estimated within the same self-regulation subsample (Table 8, Model 4; $n = 834$), self-regulation is a strong predictor, $B = 41.25$, $SE = 2.48$, $t(831.00) = 16.65$, $p < .001$, and age also retained a small but significant positive effect, $B = 1.62$, $SE = 0.70$, $t(830.50) = 2.32$, $p = .021$. In standardized terms, this corresponded to a substantial effect for self-regulation, $\beta \approx .50$, and a small effect for age, $\beta \approx .07$. Notably, because Models 1 and 4 were estimated on different samples (full sample vs. self-regulation subsample), a direct comparison of their age coefficients would not constitute a valid test of mediation or attenuation. Within the subsample in which self-regulation was measured, age remained a significant predictor of digital maturity after controlling for self-regulation. This was supported.

Table 8

Linear Mixed-Effects Models Predicting Overall Digital Maturity (H1–H4)

Predictor	Model 1 (H1) Linear age	Model 2 (H2) Nonlinear age	Model 3 (H3) Self-regulation	Model 4 (H4) Combined
Fixed effects				
Intercept	330.45*** *[6.33]*	362.82*** *[3.30]*	237.08*** *[8.14]*	215.32*** *[12.38]*
Age	2.24*** *[0.38]*	2.25*** *[0.39]*	—	1.62* *[0.70]*
Age² (centered)	—	−0.04 *[0.22]*	—	—
Self-regulation	—	—	41.93*** *[2.47]*	41.25*** *[2.48]*
Model information				
n	3,831	3,831	834	834
Countries	7	7	3	3
σ^2*country*	69.37	69.42	42.29	39.50
σ^2*residual*	1,619	1,620	1,311	1,305
AIC	39,206	39,209	8,358	8,354
BIC	39,231	39,240	8,377	8,378

Note. Each column represents a separate model. Unstandardized coefficients (*B*) are shown with standard errors in brackets below. Models were estimated with restricted maximum likelihood (REML). Country was included as a random intercept (σ^2country) to account for clustering; σ^2residual is the level-1 residual variance. Fixed effects were tested using Satterthwaite approximations. Age was centered in Model 2 before squaring. Models 3 and 4 were estimated in the self-regulation subsample only ($n = 834$, 3 countries). Null model fit (intercept + random intercept only, full sample): AIC = 39,239; BIC = 39,258. * $p < .05$. ** $p < .01$. *** $p < .001$.

Country Differences in Digital Maturity

The fifth hypothesis predicted that mean levels of digital maturity would differ across countries. Country differences in digital maturity were significant at the omnibus level, $F(6, 3824) = 19.60$, $p < .001$, $\eta^2 = .030$, with the same conclusion under the Welch correction, $F(6, 1217.61) = 21.60$, $p < .001$ (Table 9). The country model explained 3.0% of the variance in digital maturity, adjusted $R^2 = .028$.

Levene's test indicated a violation of the homogeneity of variances assumption, $F(6, 3824) = 3.50$, $p = .002$. Therefore, Games-Howell post hoc comparisons were used. Because Denmark showed the lowest mean digital maturity score in the present sample, comparisons involving Denmark are reported in Table 10. These comparisons showed that Denmark scored significantly lower than all other countries, all *p* values $\leq .010$. The broader pattern of country differences is summarized in Table 11. Slovakia also scored lower than Austria, Greece, the United Kingdom, and Spain, but did not differ significantly from Germany. Germany scored lower than Greece and Spain, but did not differ significantly from Austria, the United Kingdom, or Slovakia. Austria, Greece, the United Kingdom, and Spain did not differ significantly from one another. The fifth hypothesis was supported, although the effect size was small.

Table 9

Country Differences in Digital Maturity

Omnibus Tests				
Test	**Statistic**	***p***	***η²***	***ω²***
One-way ANOVA	$F(6, 3824) = 19.60$	< .001	.030	.028
Welch ANOVA	$F(6, 1217.61) = 21.60$	< .001	—	—
Levene's test	$F(6, 3824) = 3.50$	.002	—	—

Note. Omnibus country tests and the assumption checks are reported.

Table 10

Games–Howell Comparisons Between Denmark and All Other Countries

Comparison	**Mean difference**	***SE***	***t***	***df***	***p***	**95% CI**
Denmark – Germany	−13.37	2.10	−6.38	1182.4	< .001	[−19.57, −7.18]
Denmark – Austria	−18.29	2.09	−8.75	1170.0	< .001	[−24.47, −12.12]
Denmark – Greece	−21.77	2.77	−7.85	531.6	< .001	[−29.97, −13.56]
Denmark – United Kingdom	−20.24	2.89	−7.00	638.7	< .001	[−28.80, −11.69]
Denmark – Spain	−24.07	2.90	−8.31	517.1	< .001	[−32.64, −15.50]
Denmark – Slovakia	−8.53	2.47	−3.45	953.0	.010	[−15.83, −1.23]

Note. Negative mean differences indicate lower digital maturity scores in Denmark relative to the comparison country. Games–Howell tests were used because Levene's test indicated unequal variances (see Table 9).

Table 11

Descriptive Statistics of Digital Maturity by Country and Games-Howell Grouping

Country	***n***	***M***	***SD***	**Group**
Denmark	530	347.80	37.48	a
Slovakia	463	356.33	39.99	b
Germany	997	361.17	41.71	bc

Country	*n*	*M*	*SD*	Group
Austria	972	366.09	40.90	cd
United Kingdom	340	368.04	44.06	cd
Greece	260	369.56	36.17	d
Spain	269	371.87	39.28	d

Note. Countries are ordered by mean digital maturity. Means sharing at least one letter did not differ significantly according to Games-Howell post hoc comparisons. Countries with no shared letter differed significantly from each other.

Exploratory Analysis: Socioeconomic Status

To further contextualize digital maturity, exploratory analyses examined subjective socioeconomic status (SES). Bivariate analyses showed a small positive correlation between SES and digital maturity ($r = .10$, $p < .001$). SES was weakly negatively associated with age ($r = -.04$, $p = .014$) and was not significantly associated with self-regulation ($r = .05$, $p = .171$).

A simple linear regression indicated that SES significantly predicted digital maturity in the full sample, $B = 2.69$, $SE = 0.42$, $t(3829) = 6.41$, $p < .001$, $R^2 = .011$. In contrast, SES did not significantly predict self-regulation, $B = 0.01$, $SE = 0.01$, $t(832) = 1.37$, $p = .171$, $R^2 = .002$.

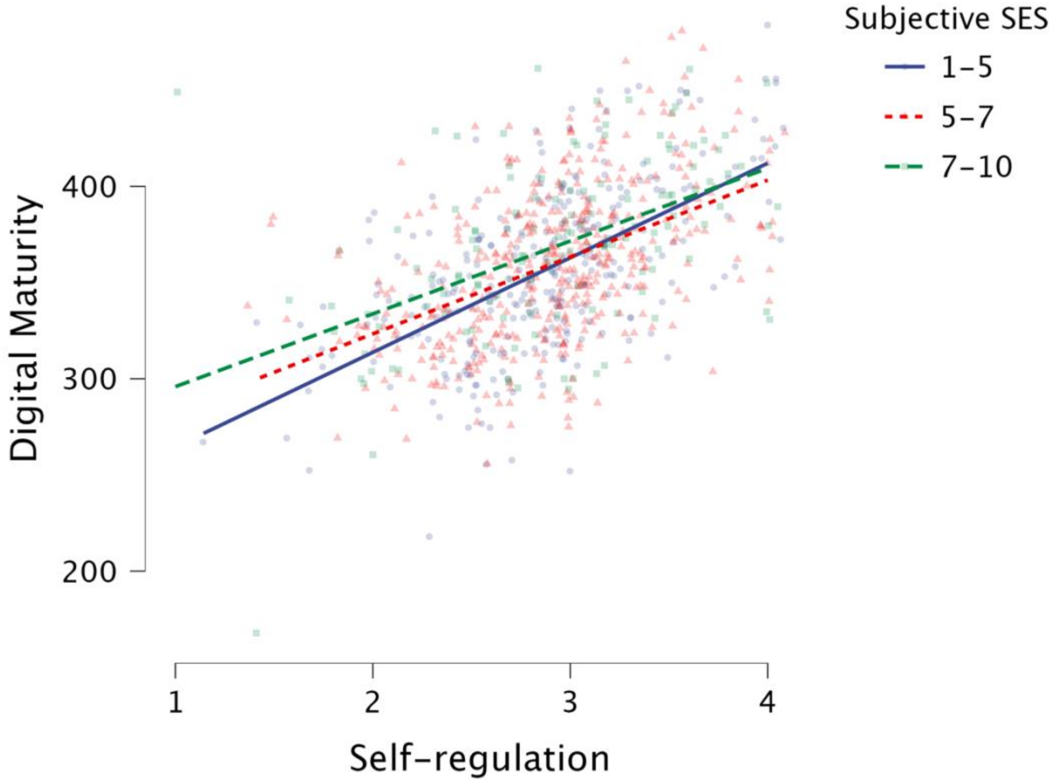
To test whether SES explained variance in digital maturity beyond age and self-regulation, a linear mixed-effects model was estimated in the self-regulation subsample ($n = 834$), with country included as a random intercept. Self-regulation ($B = 40.78$, $SE = 2.47$, $p < .001$), SES ($B = 2.40$, $SE = 0.80$, $p = .003$), and age ($B = 1.84$, $SE = 0.70$, $p = .009$) were all significant predictors.

Finally, an exploratory moderation analysis showed a significant negative interaction between centered SES and centered self-regulation, $B = -3.25$, $SE = 1.43$, $t(830) = -2.28$, $p =$

.023. This interaction indicates that the positive association between self-regulation and digital maturity was stronger at lower levels of SES and weaker at higher levels of SES. As shown in Figure 5, the slope between self-regulation and digital maturity was steepest in the lower SES group, whereas the lines converged at higher levels of self-regulation.

Figure 5

Self-Regulation and Digital Maturity Across SES Groups



Note. Points represent individual participants. This analysis was based on the self-regulation subsample (*n* = 834).

Discussion

The present study examined whether digital maturity varies across adolescence, how it relates to self-regulation, and whether mean levels differ across national contexts. The findings provide three main insights. First, digital maturity was positively associated with age, although this age-related pattern was modest and was not uniform across all dimensions.

While the overall digital maturity score showed a linear age-related increase, some dimensions showed distinct patterns, including curvilinear associations for digital literacy and autonomous choice to use mobile devices. Second, self-regulation was strongly associated with digital maturity, but age remained a small positive predictor even after self-regulation was controlled. This suggests that digital maturity is closely related to general self-regulatory capacity, but cannot be fully reduced to it. Third, mean levels of digital maturity differed across countries, indicating that digital maturity may also be shaped by broader national and contextual conditions.

Digital Maturity Across Adolescence

As expected, older adolescents reported higher digital maturity than younger adolescents. This supports the idea that digital maturity develops across adolescence and is not only a fixed personal characteristic. The finding also fits with broader developmental theories suggesting that adolescents become more responsible, self-controlled, and socially mature with age (Bleidorn, 2024; Klimstra et al., 2018). It is also consistent with previous research on digital maturity. Hofmans et al. (2024) found that older participants showed higher digital literacy and needed less support when dealing with digital problems, while the overall structure of digital maturity remained similar across age groups.

However, the age effect in the present study was small. This means that older adolescents tended to report higher digital maturity, but age explained only a limited part of the differences between adolescents. Chronological age alone therefore seems to be a weak indicator of digital maturity. Other factors, such as digital experience, socialization, support from parents or schools, and the broader digital context, may be just as important for understanding why some adolescents show higher digital maturity than others.

The dimension-specific analyses showed that age-related differences were not the same across all dimensions of digital maturity. Positive age-related differences were most evident for digital literacy, autonomy within digital contexts, digital citizenship, and respect toward others online. These dimensions likely reflect competencies that develop through repeated experience with digital environments, such as understanding digital tools, making more independent choices online, interacting responsibly with others, and using digital media for broader social purposes. This pattern supports the idea that digital maturity is not only related to general self-regulatory development, but also involves domain-specific learning and socialization in digital contexts (Laaber et al., 2023; OECD, 2025).

The pattern was less consistent for dimensions more directly related to regulation. Regulation of negative emotions in digital contexts and regulation of impulses in digital contexts did not show reliable age-related differences, even though impulse regulation has been identified as a central component within the digital maturity network (Hofmans et al., 2024). This suggests that the small overall age effect was not driven by a uniform increase in all self-regulatory dimensions. Instead, the findings fit the idea that adolescent development is uneven: adolescents may gain digital knowledge and experience while still facing strong social and motivational demands in digital environments (Wesarg-Menzel et al., 2023; OECD, 2025).

Support-seeking regarding digital problems and autonomous choice to use mobile devices showed different age-related patterns. Older adolescents reported lower support-seeking, which may reflect increasing digital self-sufficiency and a stronger orientation toward independence when dealing with digital problems. This interpretation is consistent with prior findings showing lower support-seeking among older individuals in digital contexts (Hofmans et al., 2024). At the same time, lower support-seeking is not necessarily adaptive in every situation. Prior work suggests that guidance from parents and other adults can support more autonomous and competent digital engagement, especially when it helps adolescents practice dealing with online risks rather than simply restricting their opportunities (Koch et al., 2024; Rodríguez-de-Dios et al., 2018).

Autonomous choice to use mobile devices appears to reflect a different process. Because this dimension captures pressured, reactive, or externally driven device use, lower scores among older adolescents do not simply indicate lower competence. Rather, they may suggest that device use becomes more socially embedded, habitual, and externally cued with age. This interpretation connects to the theoretical argument that peer feedback becomes especially important during adolescence, while digital environments provide frequent opportunities for immediate communication, social comparison, and continuous online engagement (Wesarg-Menzel et al., 2023; Boniel-Nissim et al., 2024; OECD, 2025). Under these conditions, older adolescents may become more skilled and knowledgeable digital users while also experiencing stronger pressure to remain available and responsive online.

Taken together, the dimension-specific findings suggest that the small overall age effect reflects a mixed developmental pattern rather than a uniform increase in all aspects of digital maturity. Digital literacy and socially responsible online behavior appear to increase with age, whereas some self-regulatory dimensions remain relatively stable. At the same time, autonomous choice to use mobile devices may become more difficult under increasing social and platform-related demands. This interpretation is consistent with evidence showing that lower self-regulation is more closely linked to problematic digital engagement than to screen time alone and may predict increases in problematic smartphone use over time (Howard et al., 2025; Xiao et al., 2025). Because the present data are cross-sectional, it remains unclear whether these patterns reflect adaptive autonomy, changing forms of digital independence, or growing vulnerability to reactive device use. Longitudinal research is needed to examine how these dimension-specific patterns develop over time.

The second question was whether digital maturity would show a nonlinear age-related pattern across adolescence. This expectation was based on developmental theories suggesting that early and middle adolescence can involve temporary disruptions in self-regulation, impulse control, and social maturity (Steinberg, 2007; Van den Akker et al., 2021). In the present study, however, the overall digital maturity score did not show such a maturity dip. Instead, the age-related pattern was better described as a small linear increase across the 12-to-18 age range.

This finding suggests that digital maturity may not follow the same nonlinear developmental pattern that has been described for some personality traits. One possible explanation is that digital maturity combines several different types of competencies. Some dimensions, such as digital literacy and socially responsible online behavior, may increase with accumulated digital experience, whereas dimensions more closely related to emotion and impulse regulation may remain relatively stable across adolescence. This interpretation is consistent with the dimension-specific findings, which showed limited nonlinear patterns for digital literacy and autonomous choice to use mobile devices, but no nonlinear pattern for the overall composite.

The absence of a nonlinear effect should therefore not be interpreted as evidence that nonlinear development is impossible in digital maturity. Rather, it suggests that such patterns were not detectable at the level of the overall composite in this cross-sectional sample. A longitudinal design would be needed to examine whether specific dimensions of digital maturity show temporary plateaus or declines during adolescence and whether these patterns differ across developmental contexts.

The Role of Self-Regulation

The role of self-regulation was central to the present study because digital maturity includes several capacities that depend on managing impulses, emotions, and autonomous choices in digital contexts. The findings showed a strong positive association between self-regulation and digital maturity. Adolescents with higher self-regulation also reported higher digital maturity, suggesting that general self-regulatory capacity is an important foundation for competent and responsible digital engagement.

This finding fits well with previous research showing that self-regulation is more closely related to problematic or difficult-to-control digital engagement than to screen time alone (Howard et al., 2025). It is also consistent with longitudinal evidence suggesting that lower self-regulation can predict increases in problematic smartphone use over time (Xiao et al., 2025). The present study extends this literature by showing that self-regulation is not only related to problematic use, but also to a broader competence-based construct that includes autonomy, literacy, risk awareness, respectful interaction, and digital citizenship.

At the same time, the findings do not imply that digital maturity is identical to self-regulation. Digital maturity also includes domain-specific knowledge, risk awareness, support-seeking, and socially responsible behavior online (Laaber et al., 2023). The strong association with self-regulation therefore suggests that self-regulation is an important developmental foundation for digital maturity, but not the whole construct. This distinction is important because adolescents may have general regulatory capacities, but still differ in how these capacities are applied in digital environments.

A further question was whether age-related differences in digital maturity could be explained by general self-regulation. In the subsample in which self-regulation was measured, age remained a small but significant positive predictor of digital maturity after self-regulation was controlled. This suggests that digital maturity is not fully captured by general self-regulatory capacity. Rather, age-related differences in digital maturity may also reflect domain-specific knowledge, experience, and socialization in digital contexts, such as understanding online risks, platform dynamics, and norms of digital communication. This interpretation is consistent with validation evidence showing that the DIMI predicts unique variance beyond broad personality traits, age, and usage amount, and beyond self-regulation in relation to well-being outcomes (Laaber et al., 2023; Laaber et al., 2024).

This conclusion should still be interpreted with some methodological caution. The age-only model was estimated in the full sample, whereas the combined model including self-regulation was estimated in the self-regulation subsample. Therefore, the two age coefficients should not be directly compared as evidence of mediation or attenuation. However, the self-regulation subsample was still sufficiently large for the present analysis. The main conclusion is therefore that, within the subsample for which self-regulation was available, age explained a small amount of unique variance in digital maturity beyond self-regulation. Future studies should assess age, self-regulation, and digital maturity within the same participants and assessment waves. Such designs are needed because cross-sectional age differences cannot show whether digital maturity changes within individuals over time or whether the observed associations reflect differences between age cohorts, as the digital involvement of younger generations has shown a steady increase over the past years (OECD, 2025; Rohrer, 2025).

Country Differences in Digital Maturity

The findings also suggest that digital maturity is partly shaped by broader contextual conditions. Mean levels of digital maturity differed across countries, although the effect was modest, with country accounting for approximately 3% of the variance in digital maturity. This finding is important because it indicates that digital maturity should not be understood only as an individual developmental outcome. Rather, adolescents' digital maturity may also depend on the national and socio-cultural contexts in which digital technologies are used, taught, regulated, and supported.

This interpretation is consistent with the neo-ecological framework, which conceptualizes digital environments as developmental contexts embedded within broader macrosystemic conditions, including national culture, educational practices, and regulatory environments (Navarro & Tudge, 2023). It also aligns with cross-national research suggesting that national context is associated with both the overall level of digital maturity and the relative importance of its dimensions (Christensen et al., 2025). Possible contextual influences include differences in digital education, norms around autonomy and risk, parental mediation practices, and opportunities to develop digital citizenship. However, these mechanisms were not directly tested in the present study. The country differences should therefore be interpreted as evidence that context may matter, but not as evidence for specific national causes.

The finding that Denmark showed the lowest mean digital maturity score was unexpected and should be interpreted cautiously. Country-level rank differences in a single cross-sectional sample may reflect sampling variability, recruitment differences, or other unmeasured contextual factors. This pattern should therefore be replicated in independent samples before strong country-specific interpretations are drawn. Future research could also examine whether countries differ not only in average levels of digital maturity, but also in the associations between digital maturity and developmental predictors such as age, self-regulation, and socioeconomic background.

Exploratory Socioeconomic Findings

As an exploratory analysis, the association between subjective socioeconomic status (SES) and digital maturity was examined. SES showed a small positive association with digital maturity that persisted after accounting for self-regulation and age. In contrast, SES was not significantly associated with self-regulation in the present sample, suggesting that SES was linked to digital maturity in a way that was not mirrored by a comparable association with self-regulation. This is consistent with Koch et al. (2024), who found that the SES-digital maturity association is fully mediated by active parental mediation: parents with higher SES engage more frequently in instructive guidance about digital risks and opportunities, which in turn fosters more autonomous digital engagement in their children. The exploratory interaction between self-regulation and SES further suggested that dispositional self-regulation may play a stronger compensatory role at lower SES levels.

Limitations and Future Research

Several limitations should be considered. First, the cross-sectional design means that age-related findings reflect differences between cohorts rather than within-person change. It is not possible to determine whether individual adolescents' digital maturity increases as they age, and cohort differences in generational digital experience or sampling variability could contribute to the observed patterns. Longitudinal designs tracking adolescents across the full 12-to-18 window are needed to test developmental hypotheses about digital maturity directly.

Second, the self-regulation subsample was limited to 834 participants from three countries (Denmark, Germany and Austria). Future studies should include self-regulation measures across all data collection waves and countries, allowing these associations to be examined in the full multi-country sample.

Third, self-regulation was measured using the Self-Regulation Scale (Luszczynska et al., 2004), which emphasises attentional control and task persistence. While this captures an important component of dispositional self-regulation, it does not represent the full multidimensional construct, which also includes emotional regulation, inhibitory control, and working memory (Wesarg-Menzel et al., 2023). Given that several DIMI dimensions specifically address emotion and impulse regulation in digital contexts, a broader self-regulation measure might yield stronger or more differentiated associations. Future research should examine whether distinct self-regulation components differentially predict digital maturity dimensions.

Fourth, country was treated as a categorical variable. This means that the analyses can show whether digital maturity differed between countries, but they cannot explain why these differences occurred. In addition, although the questionnaires were translated using standardized procedures, the present study did not formally test whether the DIMI worked in the same way across countries. The country differences should therefore be interpreted with caution. Without evidence for measurement invariance, especially scalar invariance, mean differences may partly reflect translation effects, response styles, or differences in how items were understood, rather than true differences in digital maturity (Putnick & Bornstein, 2016). Future research should test measurement invariance before making strong cross-national comparisons and include country-level indicators, such as digital education policies, parental mediation norms, or platform regulations, to better explain contextual differences.

Fifth, the sample was recruited through online panel providers, which may limit representativeness. Online panels can be affected by coverage and self-selection biases, because participation may depend on internet access, willingness to take part in online surveys, and interest in the survey topic (Bethlehem, 2010; Keusch, 2015). Therefore, replication with school-based or population-representative samples would strengthen the generalizability of the findings.

Sixth, attention-check information was not available consistently across study waves and countries, which meant that inattentive responding could not be screened in a uniform way across the full sample. This limits the extent to which data quality can be evaluated consistently and may have introduced additional measurement noise into the analyses.

Practical Implications

Overall, the results suggest that digital maturity is not simply a reflection of age or general self-regulation. Instead, it appears to be a more specific competence that develops in digital contexts. The findings also show that the different dimensions of digital maturity do not develop in the same way and that broader socio-cultural contexts may play a role. To avoid repeating these points, this section focuses on the practical implications for schools, policymakers, and digital platforms.

For schools and educators, the results suggest that digital literacy and digital citizenship are useful targets for structured educational programs. Both dimensions showed positive age-related associations and can be directly addressed in school curricula. For example, schools can teach students how to evaluate online information, understand privacy risks, participate responsibly in digital spaces, and engage with social or civic issues online. In contrast, competencies related to emotion and impulse regulation in digital contexts did not show clear age-related increases in this sample. This does not mean that interventions in these areas are effective, as this was not tested in the present study. However, it suggests that these competencies may not simply improve because adolescents grow older or spend more time online. They may need more explicit and continuous support. This could include classroom discussions about online conflicts, exercises that help students pause before reacting to upsetting messages, and reflection on platform features that encourage habitual or impulsive use. The DIMI may be useful in this context because it offers a validated way to assess adolescents' digital maturity profiles and identify areas where additional support may be needed.

For policymakers, the observed country differences suggest that national digital education policies may matter. However, as noted above, these differences should be interpreted carefully because measurement invariance across countries was not formally tested. Therefore, the results should not be read as strong country rankings. Rather, they indicate that digital maturity may be connected to broader educational, cultural, and regulatory conditions. Previous research also shows that the association between socioeconomic status and digital maturity is mediated by active parental mediation (Koch et al., 2024). This suggests that policies supporting informed and engaged digital parenting may be particularly important for adolescents from lower socioeconomic backgrounds. At the level of digital platforms, the findings point to the importance of design features that reduce exploitative or overly engaging mechanics. This may be especially relevant for younger adolescents, who are still developing regulatory capacities while also being particularly sensitive to rewards and social feedback (Steinberg, 2007; OECD, 2025).

More broadly, the findings suggest that growing up in a digitally connected world requires more than access to technology or basic technical skills. Responsible digital engagement cannot be assumed to develop automatically through age or repeated digital exposure alone. This is relevant for current Austrian policy initiatives such as the Digitale Kompetenzoffensive (Bundesministerium für Wirtschaft, Energie und Tourismus, 2022) and the compulsory school subject Digitale Grundbildung (Hörmann et al., 2023). Supporting adolescents in digital environments therefore requires attention not only to digital access and literacy, but also to the regulatory, social, and civic competencies that shape how digital technologies are actually used.

Conclusion

This study provides cross-national evidence that digital maturity is associated with age and self-regulation across adolescence, and that it differs across national contexts. The findings suggest that digital maturity is closely related to general self-regulatory capacity, but not fully explained by it. Age remained uniquely associated with digital maturity after accounting for self-regulation, and the dimension-level results showed that age-related differences were more evident in some aspects of digital competence than in others. Overall, these findings indicate that fostering digital maturity requires attention not only to digital skills, but also to the self-regulatory and contextual factors that support competent, reflective, and responsible digital engagement.

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Declaration of Artificial Intelligence Usage

In the preparation of this thesis, I used the artificial intelligence tool OpenAI ChatGPT as a supportive aid for language, structure, and revision. All content included in the final version of this thesis was reviewed and revised where necessary. Examples of prompts used include:

- "Please change non-academic wording and correct the grammar of this sentence without changing the meaning."
- "Please give me feedback to the structure and clarity of the text."

Appendix A: Correlation Matrix of Study Variables and Digital Maturity Dimensions

Table A1

Pearson Correlation Matrix of Study Variables and Digital Maturity Dimensions

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	—												
2. Self-regulation	.12***	—											
3. Digital maturity	.09***	.52***	—										
4. Autonomous Choice to Use Mobile Devices	−.06***	.23***	.48***	—									
5. Autonomy Within Digital Contexts	.11***	.24***	.31***	.00	—								
6. Digital Literacy	.30***	.37***	.48***	.01	.22***	—							
7. Individual Growth in Digital Contexts	.01	.18***	.43***	−.09***	.10***	.21***	—						
8. Digital Risk Awareness	.04*	.40***	.68***	.20***	.13***	.24***	.27***	—					
9. Regulation of Negative Emotions in Digital Contexts	−.01	.25***	.51***	.44***	.08***	.11***	−.03*	.15***	—				
10. Regulation of Impulses in Digital Contexts	.02	.20***	.55***	.46***	.05**	.05**	−.02	.24***	.49***	—			
11. Support-seeking Regarding Digital Problems	−.14***	.20***	.42***	.08***	.07***	−.03*	.18***	.28***	.03	.07***	—		
12. Respect Towards Others in Digital Contexts	.05**	.40***	.69***	.20***	.23***	.23***	.22***	.50***	.21***	.35***	.32***	—	
13. Digital Citizenship	.10***	.09**	.28***	−.18***	−.14***	.19***	.37***	.21***	−.16***	−.15***	.11***	.12***	—

Note. Values are Pearson correlations. The age–digital maturity correlation was based on N = 3,831; correlations involving dimension scores but not self-regulation were based on n = 3,800; correlations involving self-regulation were based on the available self-regulation subsample (n = 834). * $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix B: Measures and Internal Consistencies

Table B1

Items of the Final 32-Item Digital Maturity Inventory and Cronbach's Alpha by Dimension

Dimension	No.	Item	Cronbach's α
Autonomous Choice to Use Mobile Devices	1	I am online because I feel like I have to be online all the time. **(R)**	.820
	2	I am online because otherwise I feel like I am missing out on something. **(R)**	
	3	I have the feeling that it is controlling my life. **(R)**	
Autonomy Within Digital Contexts	1	I choose the content I want to see.	.811
	2	I decide what I do.	
	3	I do the things that I like.	
Digital Literacy	1	I know how to change the privacy settings, for example, deactivate cookies.	.822
	2	I know how to adjust the privacy settings of social media sites, for example, Instagram, Snapchat, TikTok.	
	3	I know how to store photos, documents or other files in the cloud, for example, Google Drive, iCloud.	
Individual Growth in Digital Contexts	1	I learn new things.	.867
	2	I learn something useful.	
	3	I learn new skills.	
Digital Risk Awareness	1	I am very careful.	.883
	2	My own safety is very important to me.	
	3	I make sure to be careful.	
Support-Seeking Regarding Digital Problems	1	I ask others for help when I have a problem.	.857
	2	...and there is a technical problem, I ask others for help, for example, a friend, parent, sibling.	
	3	...and I do not know what to do, I ask others for help.	

	4	...and I have problems with others on the internet, I get help.	
Regulation of Negative Emotions in Digital Contexts	1	...and I become annoyed or upset online, it takes me a long time to feel better. **(R)**	.874
	2	...and I become annoyed or upset online, there are only few things that can make me feel better. **(R)**	
	3	...and I become annoyed or upset online, I stay in a bad mood for a long time. **(R)**	
Regulation of Impulses in Digital Contexts	1	...and somebody criticizes me online or in a text, I immediately react without considering the consequences. **(R)**	.832
	2	...and somebody insults me, I try to get back at them. **(R)**	
	3	...and a message makes me angry, I react too quickly and then later regret the way I responded. **(R)**	
Respect Toward Others in Digital Contexts	1	I watch my language when I disagree with someone, so that what I say does not come across as mean.	.812
	2	I respect the opinions and knowledge of others.	
	3	I care about the feelings of others.	
	4	I make sure that pictures I post or send of other people will not insult them or get them into trouble.	
Digital Citizenship	1	I use it to improve life in my neighborhood, town or world.	.870
	2	I use the internet to support campaigns for issues like environmental protection or to spread awareness for climate change.	
	3	I use it to stand up for things that really matter in the world.	

Note. Items marked with **(R)** were reverse-coded before dimension scores were computed. Items beginning with ... follow the common stem *"When using a mobile device..."* Most items were rated on a five-point Likert scale ranging from 1 (*"never")* to 5 (*"always"*). Items from the digital literacy dimension were rated on a scale from 1 (*"not at all true of me"*) to 5 (*"very true of me"*). Cronbach's alpha is reported separately for each dimension (Laaber et al., 2023).

Table B2

Items of the Self-Regulation Scale

No.	Item
1	I can concentrate on one activity for a long time, if necessary.
2	If I am distracted from an activity, I don't have any problem coming back to the topic quickly.
3	If an activity arouses my feelings too much, I can calm myself down so that I can continue with the activity soon.
4	If an activity requires a problem-oriented attitude, I can control my feelings.
5	I can control my thoughts from distracting me from the task at hand.
6	After an interruption, I don't have any problem resuming my concentrated style of working.
7	I stay focused on my goal and don't allow anything to distract me from my plan of action.

Note. Items are from the Self-Regulation Scale (Luszczynska et al., 2004). Items were rated on a four-point Likert scale ranging from 1 *("not true")* to 4 (*"completely true").* The overall self-regulation score was computed by averaging the seven items.