

Chapter 12

Digital Well-Being and Learner Development: Problematic Internet Use, Attitudes, and Self-Regulation

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1. Introduction

The following classroom vignette is a fictional, illustrative scenario constructed by the author to introduce the chapter's central themes. It does not describe an observed case: "Science class at the middle school is on Cell Division and Genetics. The instructor told the class to use the AR application and virtual microscope on their tablets to examine the relevant images and observe the phases of mitosis. At the front of the class Deniz is watching chromosomes that are moving in a 3D space toward opposite poles on her tablet. In order to satisfy her desire for knowledge of a concept, she is utilizing digital technology. Ali, however, is sitting toward the back of the room. A light on his tablet is beginning to flash and he finds himself being distracted by something else entirely. He closes the augmented reality application, logs into his social networking website and checks his notifications." The act shown is an example of "academic cyberslacking," which is defined as "a student's use of the internet for something not academic while in school" (Simanjuntak et al., 2022). By the end of the class, Ali appears disengaged from the remainder of the lab activity—illustrating how a brief lapse in attention can compound over a lesson, though this single incident is not, on its own, evidence of guilt, tension, or lasting functional loss—while Deniz remains engaged with the simulation, consistent with focused, goal-directed technology use, without implying that she has thereby mastered the topic. Ali's use of technology illustrates how the same tool can serve as either an aid or a distraction in science classes, depending on how it is used (Mourlam et al., 2020).

Making information available and improving multimedia learning depend critically on digital tools in 21st-century education. This is particularly true in disciplines like science education, where visualizing complex concepts is essential. Simulations and digital models may increase pupils' passion for learning by making abstract phenomena visible and interactive. However, the pervasive presence of mobile technologies that enable constant connectivity may create pressure on students to remain connected online, therefore impeding their attention. A review of current research reveals that this problem transcends straightforward distractions; it is connected to what is known as "Problematic Internet Use" (PIU), characterized by a person's difficulties in regulating their internet habits and the resulting detrimental effects on their academic, social, and psychological health (Caplan, 2010; Y. Ozdemir et al., 2014). Higher levels of problematic internet use have been associated with greater stress and less adaptive coping patterns among university students (Evgin et al., 2025). In science-learning contexts, such findings may be relevant to students' ability to sustain attention and manage cognitively demanding tasks, although this application represents a contextual inference.

When discussing the role of technology in education, the key concept to focus on is "digital well-being"—a term that describes the nature of the individual's relationship with technology, not the technology itself. Digital well-being is defined not merely as limiting screen time or the absence of addiction through a reductive approach, but as a dynamic state in which the individual can strike an optimal balance between the benefits and potential harms derived from digital tools (Buchi, 2024; Vanden Abeele, 2021). In the context of science education, digital well-being encompasses a student's capacity to consciously filter digital stimuli (notifications, games, social media) in the laboratory environment and use technology in alignment with academic goals. However, research indicates that

students—and even pre-service teachers—struggle to maintain this balance. Research with pre-service teachers has documented associations among internet-related risks, cyberbullying/cyber-victimization, and ICT-related characteristics (H. Ozdemir & Erokten, 2025a, 2025b). Separate evidence also links internet-addiction scores with emotion-regulation patterns (Şan et al., 2025).

One key factor shaping whether students use digital tools for learning, like Deniz, or for escaping reality, like Ali, is their “self-regulation” skills. Bandura’s Social Cognitive Theory and LaRose’s Deficient Self-Regulation framework suggest that problematic or excessive internet use can be understood partly in terms of difficulties in monitoring and regulating one’s own behavior rather than simply as a lack of willpower (Bandura, 1991; LaRose et al., 2003; Tokunaga, 2017). Students with greater self-control may be better able to resist short-term digital temptations in favor of longer-term goals, whereas lower self-control is associated with greater impulsivity and internet-addiction tendencies (S. Li et al., 2021). Therefore, when talking about the use of technology in science education, personal differences such as students’ views on technology (Tozkoparan & Yilmaz, 2018) and beliefs about their own abilities (Karakaya Ozyer & Altinsoy, 2023) should also be considered.

This book chapter aims to address, through a holistic approach, the risk factors that threaten digital well-being in the context of science education, as well as the protective mechanisms that make these risks manageable. In this chapter, the concepts of digital well-being, problematic internet use, attitudes, and self-regulation—which are typically examined separately in the literature—are synthesized to propose the “Science Education Digital Self-Regulation and Well-Being (S-DRW)” model, a conceptual framework derived from this synthesis, not an empirically validated program. It is intended to guide, and to be tested through, future research and classroom design. In light of this model, the discussion focuses on how teachers and policymakers might design pedagogical strategies that develop students’ digital self-regulation skills instead of relying on restrictive measures. Theoretical and practical implications, together with directions for empirically testing the model, are presented.

2. Digital Well-being: Conceptual Basics and Educational Context

In today’s world, where digital tools influence every part of life, schools are experiencing this change too. However, this change needs not just new tools but also a reshaping of how learners think and feel. This section defines digital well-being, examines its multidimensional structure and principal risk and protective factors, and considers its implications for science education.

2.1. What Is Digital Well-being, and What Isn’t?

In the literature, “digital well-being” is often wrongly seen as just the “lack of internet addiction” or “reducing screen time.” However, current research describes this idea not as the opposite of a harmful condition (addiction), but rather as a positive mental state where the person keeps control over their relationship with technology (Buchi, 2024; Vanden Abeele, 2021). Digital well-being is the ability to

handle the negative impacts—like distraction, stress, and loss of control—that digital tools might cause, while also benefiting from the opportunities they provide (learning, socializing, entertainment).

Gui et al. (2017) present this as the individual's capability to direct their attention and goals in a world full of digital content. Thus, digital well-being isn't about completely shutting off from technology (digital detox); instead, it's about using- technology as a mindful tool to maintain a feeling of well-being even with the strain of constant online connectivity (Burr & Floridi, 2020; Neagu & Vieriu, 2025). This state of balance isn't a fixed situation but a flexible process that the individual continuously adjusts in reaction to changing digital demands (Vanden Abeele, 2021).

2.2. Multidimensionality

Digital well-being is a complex and multidimensional concept that cannot be reduced to a single variable. Research shows that this concept has cognitive, emotional, social, and physical dimensions.

- **Cognitive Dimension:** This includes a person's skill to find information, understand information, and concentrate in an online setting. As mentioned by Al-Mansoori et al. (2023), how digital tools are designed can influence users' thinking by pulling their focus away. In science teaching, this aspect relates to learners' capability to handle their mental effort when using simulations.
- **Emotional Dimension:** It refers to the levels of happiness, satisfaction, or anxiety that digital interactions evoke in an individual. A study conducted by Ekşi et al. (2020) on adolescents found that digital gaming and smartphone addiction were negatively associated with dimensions of well-being such as happiness, optimism, and engagement. Technostress is documented as a further negative component of this dimension in digitally intensive settings, although this specific evidence comes from a study of academic staff rather than students and is extended here to the educational context by analogy (Truta et al., 2023).
- **Social Dimension:** This connects to the quality of online interaction and the view of social support. As issues with internet use grow, people may face challenges in their social connections, which can harm overall wellness. Higher levels of problematic internet use have also been linked to less adaptive coping strategies, including reduced reliance on social-support-seeking coping (Evgin et al., 2025). However, when used correctly, digital tools can aid wellness by improving social ties (Kuss & Griffiths, 2011).
- **Physical Dimension:** Excessive screen use is linked to physical issues; social media use in particular has been associated with poorer sleep quality among young people, a relationship documented across multiple studies in a systematic review (Alonzo et al., 2021).

2.3. Protective and Risk Factors

The factors that shape students' digital well-being consist of "risk" and "protective" elements that function like the two sides of a scale.

Risk Factors: The most prominent risk factors are Problematic Internet Use (PIU) and related forms of digital addiction. A recent study of university students found that higher levels of problematic internet use and digital addiction were associated with less adaptive stress-coping patterns (Evgin et al., 2025). Similarly, problematic internet use is associated with academic procrastination behaviors (Karakaya Ozyer & Altinsoy, 2023). When examining the gender factor, male pre-service science teachers have been found to report higher perceived self-efficacy in information technology, along with higher cyberbullying and cyber-victimization scores, than their female counterparts (H. Ozdemir & Erokten, 2025a).

Protective Factors: Important protective factors include self-regulation and self-control skills. A study by Muslikah et al. (2025) found that high self-control and online mindfulness were positively associated with digital well-being among university students. Emotional regulation skills are also a critical protective factor: teacher candidates with higher reappraisal-based emotion-regulation skills reported lower internet-addiction scores at low-to-average levels of daily internet use. This protective association was not significant among candidates with the highest daily use, a cross-sectional pattern, not confirmed prevention of future addiction (Şan et al., 2025). Additionally, digital literacy skills are associated with well-being by enabling students to recognize and manage online risks (Arkan & Bal, 2025).

2.4. In the Context of Science Education

These concepts, which are discussed in the context of general education, hold specific and critical implications for science education. A 2025 study of 152 science teacher candidates found that 98% reported having a computer or tablet at home, although only 80.9% owned a personal computer and 32.9% owned a personal tablet. Internet-addiction scores were significantly higher among those using the internet more than three hours per day, though usage duration alone should not be treated as a diagnostic indicator of internet addiction (H. Ozdemir & Erokten, 2025b). This situation highlights the need for future science teachers to possess not only technological pedagogical content knowledge (TPACK) but also competencies related to emotion regulation and digital well-being.

In science classrooms, where tablets can complement laboratory manuals and AR applications can complement microscope-based observation in certain settings, academic cyberloafing (non-academic internet use during class) is a relevant concern. Rather than relying solely on bans, supporting students' academic self-efficacy and self-regulation may plausibly help reduce it, although neither has yet been tested as a direct intervention for cyberloafing in the studies reviewed in this

chapter. This self-efficacy–procrastination link is discussed in more detail in Section 4.1. Therefore, science education should equip students not only with scientific literacy but also with the competency of “digital well-being”—the ability to maintain a healthy presence in the digital world.

3. Risk Patterns: Problematic Internet Use and Academic Cyberloafing

The sustainability of digital well-being depends on how well individuals can manage the risks associated with their relationship with technology. In science education settings, two key risk factors that distract students and deplete their cognitive resources come to the fore: Problematic Internet Use (PIU), a pattern of internet use associated with functional impairment across academic, social, or psychological domains, and academic cyberloafing, a related but distinct classroom behavior that may co-occur with PIU. In this section, the theoretical foundations of these two concepts, their effects on learning processes, and their interrelationships will be examined in light of current research.

3.1. Problematic Internet Use (PIU)

Problematic Internet Use (PIU) refers to maladaptive internet-related cognitions and behaviors characterized by difficulties in self-regulating internet use and by associated negative outcomes in daily functioning (Caplan, 2010; Davis, 2001). Sirakaya and Seferoglu (2013) highlight that problematic internet usage is defined by people’s inability to manage their internet use and their withdrawal or restlessness experiences when they are unable to access the internet. A recent study by H. Ozdemir and Erokten (2025b) on science teacher candidates found that internet-addiction scores were significantly higher among those using the internet more than three hours a day, indicating that PIU is more than just a matter of overall time management. Evgin et al. (2025)’s study of college students suggests that PIU is associated with “multi-screen addiction,” which is linked to raised stress levels and less adaptive stress-coping patterns. In science-learning contexts, PIU may therefore be relevant to students’ difficulty sustaining goal-directed attention when digital devices are used.

It is important to distinguish these related but non-equivalent constructs before proceeding. Problematic internet use (PIU) refers to a pattern of internet-related cognitions and behaviors that produces functional impairment across academic, social, or psychological domains (Caplan, 2010; Davis, 2001). It is not simply a matter of time spent online. Internet addiction, as used in several of the studies cited in this chapter, typically refers to a related but more clinically framed construct emphasizing compulsivity, withdrawal, and loss of control, and is often measured with different instruments than PIU. The two terms are used loosely and sometimes interchangeably in this literature, a limitation this chapter inherits from its sources. Heavy or intense use (e.g., more than three hours per day) is a quantitative, time-based indicator that may or may not co-occur with PIU or internet addiction, since duration alone does not establish impairment (H. Ozdemir & Erokten, 2025b). Academic cyberloafing is narrower still: it refers to situational, classroom-specific non-academic internet use (Simanjuntak et al., 2022) and should not, on its own, be treated as evidence that a student has trait-level PIU or internet addiction.

Self-regulation, self-control, and emotion regulation are related but distinct constructs in this chapter. Self-regulation is used as the broad, superordinate capacity to monitor and direct one's cognitive, emotional, and behavioral processes toward goals. Self-control refers more specifically to the capacity to restrain impulses in the moment, and emotion regulation refers to the management of affective states. Self-efficacy—academic, information-technology (ICT), or emotion-regulation self-efficacy—is a further, separate construct: it reflects a person's self-reported belief in their own capability, not a directly observed skill, and academic self-efficacy and ICT self-efficacy should not be treated as interchangeable protective mechanisms even though both are discussed in this chapter.

Finally, most of the studies synthesized in this chapter sampled university students, pre-service teachers, or adults, not middle- or high-school science students. Where such findings are extended to K–12 science classrooms in this chapter, this represents a contextual adaptation by the author and not a directly confirmed finding for that population.

3.2. The Effects of PIU on Learning

Problematic technology-use patterns may be relevant to students' academic motivation in educational settings. Celikkaleli et al. (2025) found that digital game addiction negatively predicted academic motivation and that problematic internet use moderated this relationship. In cognitively demanding science-learning contexts, these patterns may be relevant to students' ability to sustain attention during inquiry and problem solving; this application represents a contextual inference rather than a directly measured outcome in the cited studies. Furthermore, problematic internet use is a significant predictor of academic procrastination. Karakaya Ozyer and Altinsoy (2023) found that it significantly predicted students postponing academic work such as homework, projects, and exam preparation. This scenario compromises the concepts of consistency and scientific order which are important in science education.

3.3. Academic Cyberloafing (Cyberslacking)

While PIU is a problem in an individual's general life, academic cyberloafing is a related but distinct classroom behavior that may co-occur with this problem. The literature also uses the terms cyberslacking, cyber-idleness, and cyber loitering for closely related behavior, and this chapter uses "cyberloafing" consistently from this point onward. According to the definition by Simanjuntak et al. (2022), academic cyberloafing refers to students engaging in online activities unrelated to the class's learning objectives (checking social media, messaging, playing games, browsing irrelevant websites) during class hours. As digital devices become more common in classrooms, students' perceived ability to multitask may also be relevant to cyberloafing; Simanjuntak et al. (2022) reported a positive direct association between multitasking self-efficacy and academic cyberslacking. A study by Tozkoparan and Yilmaz (2018) on pre-service teachers found that internet addiction significantly predicted cyberloafing behavior, although two specific attitude dimensions it measured — perceptions of the nature of learning and learning openness — did not have a significant direct effect on cyberloafing in their

model. While this behavior may provide the student with immediate gratification, over time it may be associated with missing class content and academic difficulties.

3.4. The Relationship Between PIU and Cyberloafing

Research suggests an association between problematic technology-use tendencies and academic cyberloafing. In Tozkoparan and Yilmaz (2018), internet addiction significantly predicted cyberloafing among pre-service teachers. Self-regulation difficulties may be one factor linking PIU-related tendencies with classroom cyberloafing; in a related structural-equation model of university students, Gokcearslan et al. (2016) found that weaker self-regulation and a higher tendency toward cyberloafing were both significant predictors of smartphone addiction. However, the available evidence does not establish a single causal mechanism between these constructs. As noted by Şan et al. (2025), individuals with high internet addiction experience greater difficulties in regulating their emotions. When a notification arrives in the classroom or the cognitive load of the lesson increases, students with a tendency toward PIU may be more likely to respond impulsively and turn to cyberloafing.

3.5. Demographic Differences in Digital Well-being and Risks (Gender and Technology Ownership)

In the emergence of risk factors such as problematic internet use and cyberloafing, not only students' psychological characteristics but also their demographic characteristics and access to technology play a role. Recent studies in the literature indicate that gender has a differentiating effect on technology usage habits and types of risk. Research conducted by H. Ozdemir and Erokten (2025a) revealed that male teacher candidates have significantly higher levels of perceived self-efficacy in information technology, cyberbullying, and cyber victimization compared to female students. Similarly, Ekşi et al. (2020) found that males have higher digital game addiction, while females have higher smartphone addiction. Furthermore, Sirakaya and Seferoglu (2013) emphasize that male teacher candidates are more susceptible to problematic internet use. Regarding technology access, H. Ozdemir and Erokten (2025b) found that among 152 science teacher candidates, internet-addiction scores were significantly higher for those using the internet more than three hours a day than for less frequent users; usage duration alone, however, should not be treated as a diagnostic indicator of addiction.

3.6. Related Patterns of Problematic Technology Use: Digital Gaming and Social Media/Smartphone Use

Problematic internet use is a broad construct. Two related forms of problematic technology use frequently examined alongside PIU are digital gaming addiction and problematic social media or smartphone use. A comprehensive study on Turkish adolescents by Celikkaleli et al. (2025) reported that digital game addiction significantly and negatively predicted students' academic motivation. Similarly, Ekşi et al. (2020) reported that digital gaming and smartphone addiction were negatively associated with adolescents' well-being (assessed via dimensions such as engagement, optimism, and

happiness), with family harmony and self-esteem operating as mediating variables in that relationship. Specifically, social media use is one of the most prominent forms of academic cyberloafing behavior in the classroom. In the analysis of the subdimensions of academic cyberloafing, Simanjuntak et al. (2022) reported that communicating with friends about matters unrelated to the lecture was the most frequently reported behavior, followed by “posting” and “updating” on social media during class. The constant availability of social media and phone notifications may therefore provide a readily accessible source of off-task engagement when students experience the cognitive demands of a lesson.

3.7. Psychological Outcomes: Depression, Loneliness, and Psychological Resilience

Problematic internet use is associated not only with poorer academic outcomes but also with psychosocial factors such as loneliness, depressive symptoms, and emotion-regulation difficulties. A study conducted by Y. Ozdemir et al. (2014) on Turkish university students proposed a model in which low self-control acts as a bridge between negative emotional states such as depression and loneliness and internet addiction: individuals experiencing social isolation and loneliness in real life turn to the internet to escape these negative emotions due to low self-control, a pattern associated with higher internet addiction, though the cross-sectional design of this research does not establish a causal sequence. This cycle is proposed as one pathway threatening the individual’s psychosocial well-being. Similarly, Seben et al. (2013) demonstrated that depressive symptoms and weak self-regulation capacity significantly predict problematic internet use among university students. Gioia et al. (2021), through a comprehensive literature review, found that difficulties in emotional regulation are a recurring correlate of problematic internet use across the studies they reviewed.

Two psychosocial factors that may help counteract negative outcomes are psychological resilience and dispositional hope. Yilmaz and Karaoglan Yilmaz (2023) found that psychological resilience, dispositional hope, and happiness were negatively associated with problematic internet use among adults. Because these findings are based on path analysis rather than experimental evidence, they should be interpreted as associations rather than confirmed protective effects. In light of these findings, it may be valuable for science education settings to look beyond students’ cognitive skills alone and also design collaborative laboratory activities that reduce their sense of loneliness and create social interaction spaces that support their psychological resilience.

Evidence from a cross-national comparison offers a more mixed picture: comparing samples from the United States and Israel, Olenik Shemesh et al. (2024) found that problematic internet use was associated with lower well-being in the US sample, with loneliness and school disengagement acting as mediators of that relationship. The same mediation pattern did not hold in the Israeli sample, suggesting this pattern is not straightforwardly cross-cultural. Broader generalization would require samples from a wider range of cultural and educational contexts.

4. Attitudes and Self-Regulation: Mechanisms That Turn Risk into an Opportunity for Learning

The presence of digital devices in science labs or online learning environments does not, on its own, guarantee learning, nor does it necessarily lead to absolute distraction. The key factors determining whether a student will turn these tools into an opportunity or a risk are their internal psychological mechanisms. In this section, learners' attitudes toward digital technologies, their self-efficacy beliefs, their self-regulation capacities that enable them to control their impulses, and digital self-control tools (DSCTs) as an external support will be examined in a multidimensional manner based on current research.

4.1. Attitudes Toward Digital Technologies and Digital Learning and Self-Efficacy

Attitude reflects the mental dispositions and beliefs an individual develops toward an object, situation, or tool, and such attitudes may influence behavioral intentions. In educational settings, the way students use digital tools is largely shaped by their attitudes toward learning and technology. Indeed, a study of pre-service teachers found that the two measured attitude dimensions—perceptions of the nature of learning and learning openness—did not significantly predict cyberloafing directly, whereas internet addiction did (Tozkoparan & Yilmaz, 2018). Students' motivation toward a course and their perception of a learning task may still plausibly relate to their engagement in non-class-related online content, such as games, social media, and news, though this specific link remains to be empirically confirmed.

A related but distinct construct is self-efficacy, which refers to individuals' beliefs about their capabilities rather than their attitudes toward technology. Karakaya Ozyer and Altinsoy (2023) found that university students with high academic self-efficacy beliefs exhibited less procrastination in their academic tasks. One possible explanation is that students with high academic self-efficacy may view digital tools as aids that help them pursue their academic goals instead of giving up in the face of challenges. Similarly, H. Ozdemir and Erokten (2025a) assessed ICT self-efficacy among pre-service science teachers; however, they did not find a significant relationship between ICT self-efficacy and internet-addiction scores. Therefore, whether ICT self-efficacy helps protect against problematic internet use remains a question for future empirical research.

4.2. Self-Regulation, Self-Control, and Emotional Regulation Skills

Self-regulation is the ability to monitor, evaluate, and direct one's own cognitive, emotional, and behavioral processes in order to achieve self-set goals. As noted in other studies, according to the "Deficient Self-Regulation" approach, problematic internet use and digital addictions are not simply a

result of a lack of willpower, but rather a consequence of the individual's failure to consciously monitor and restrict their own digital habits (LaRose et al., 2003; Tokunaga, 2017).

This view is consistent with Billieux and Van der Linden's (2012) review linking problematic internet use to impulsivity, sensation-seeking, and weak inhibitory control, reinforcing the conceptual link between self-regulation deficits and problematic technology use more broadly.

A large-scale meta-analysis of 83 studies ($N = 80,681$) by S. Li et al. (2021) found a significant negative relationship between self-control and internet addiction among students, moderated by culture, gender, and the measurement instrument used (age moderated a related impulsivity-addiction link examined in the same meta-analysis — impulsivity being one of two self-control dimensions the study distinguished, alongside restraint — but not the restraint-based self-control-addiction link specifically)—underscoring self-control as one consistent correlate, though not the sole explanation, of problematic internet use.

Current research highlights three interrelated constructs relevant to self-regulation and digital well-being:

- 1. *Emotion Regulation:*** Celikkaleli et al. (2025), in a study of 1,156 Turkish adolescents, found that digital game addiction negatively predicted academic motivation. Emotional regulation self-efficacy beliefs—that is, adolescents' self-reported perceived capacity to regulate emotions, not a directly observed skill—partially mediated this relationship, while problematic internet use separately moderated the negative effect of digital game addiction on academic motivation, attenuating rather than intensifying it at higher PIU levels: the negative effect was strongest among adolescents with low PIU and became non-significant among those with high PIU; this attenuation pattern describes how the digital-game-addiction-motivation relationship varies across PIU levels and should not be read as evidence that problematic internet use itself is beneficial or protective. Similarly, Şan et al. (2025) found that reappraisal-based emotion regulation moderated the relationship between daily internet use and internet-addiction scores: individuals with high reappraisal ability showed lower addiction scores at low and average usage durations, though this protective association was not significant among those with the highest usage durations. Because this is a cross-sectional finding, it indicates a concurrent protective association, not confirmed prevention of future addiction development.
- 2. *Self-Control and Mindfulness:*** In a study conducted by Muslikah et al. (2025), high self-control skills and “online mindfulness” were found to be positively associated with digital well-being among university students. Because this finding comes from a mediation analysis, not an experimental design, it points to an association instead of a confirmed direct effect. In that study, higher online mindfulness was associated with greater digital well-being and partially mediated the relationship between self-control and digital well-being.
- 3. *Emotional Intelligence:*** Emotional intelligence, defined as the ability to perceive, understand, and manage one's own and others' emotions, is a related construct relevant to emotional and self-regulatory functioning. Using partial least squares structural equation modeling (PLS-SEM) with

middle-school students, Mascia et al. (2020) found that self-regulation was positively associated with quality of life and that these constructs were interrelated with smartphone addiction within their model. Consistent with this, Evren et al. (2018) reported that greater difficulty in emotion regulation was associated with more severe internet addiction among young adults, and Karaer and Akdemir (2019) found that adolescents with internet addiction who reported lower perceived social support and less favorable parenting-style profiles also reported greater difficulty regulating their emotions. Taken together, these cross-sectional findings converge on emotion-regulation difficulty as a correlate of problematic technology use, though—as with the other correlational findings reviewed in this chapter—they do not establish that improving emotion regulation causes reduced addiction.

4.3. Academic Procrastination in Online and Distance Learning Environments

The use of technology in education is not restricted to conventional classroom and laboratory environments. Students' self-regulation skills have been most challenged by the online learning processes they do on their own outside of class. Karakaya Ozyer and Altinsoy (2023) investigated the relationship between academic procrastination behaviors and problematic internet use of university students in an online learning environment. The study found that, among students learning independently online, higher problematic internet use was associated with greater vulnerability to non-academic online distraction and a greater tendency to postpone academic tasks. Similarly, studies in the literature have reported an association between the overuse of non-educational mobile applications (social media, messaging) and academic procrastination behaviors, including avoidance of academic tasks (Kaur, 2021).

Neagu and Vieriu (2025) note that digital engagement in higher education has complex implications for students' digital well-being. While constant access to digital resources is beneficial for academic performance, it also paves the way for cognitive overload and technology-induced stress (technostress). Karakaya Ozyer and Altinsoy (2023) found that self-regulated online learning partially mediated the association between problematic internet use and academic procrastination: higher problematic internet use was associated with lower self-regulated learning, which was in turn associated with greater procrastination. This mediated association should not be interpreted as evidence of statistical buffering or as evidence that an intervention reduces risk.

The rapid, system-wide shift to remote and online learning during the COVID-19 pandemic intensified these self-regulation demands. Al Lily et al. (2020) and Xie et al. (2020) both argued that while digital platforms provided valuable flexibility during this emergency shift, they also placed considerable strain on students' digital well-being and academic concentration when students were left to manage their own learning environments at home, with fewer external structures than a physical classroom provides. These accounts are based on conceptual and descriptive analyses of the pandemic-era shift, not controlled empirical comparisons, and should be read accordingly. Whether these pressures produced lasting change in students' digital habits remains an open empirical question, discussed further in this chapter's conclusion.

4.4. Digital Self-Control Tools (DSCTs)

In recent years, several kinds of software and applications have been developed using digital technology itself to support the internal self-regulation capacity of students. These systems are known in the literature as “Digital Self-Control Tools” (DSCTs) and aim to assist users in voluntarily restricting their use of technology to reach digital well-being. According to a recent comprehensive meta-analysis study, these tools have moved from simple “screen time tracking” to complex interventions that include blocking applications, goal setting, and reward-punishment mechanisms (Monge Roffarello & De Russis, 2023).

For example, when a student conducting research in a science lab or preparing for an exam at home uses tools that block distracting social media apps during class time or issue alerts when the usage limit is reached, these tools function as an external aid to self-regulation—a “prosthesis for the will”—in cases of inadequate self-regulation. A large-scale survey of Swedish adults found that digital self-control—the ability to resist impulses to overuse digital media—was positively associated with digital well-being and life satisfaction (Mayiwar et al., 2025). It has been stated that for the effectiveness of these tools to be sustainable in the long term, simply restricting access is insufficient. Rather, the design must be built upon theories that support the user’s “meaningful interaction” (Monge Roffarello & De Russis, 2023).

4.5. The Relationship Between Science Education and the Attitude-Self-Regulation-Risk Continuum

The implications of all these psychological and technological mechanisms for science education are quite critical. By its very nature, science education requires higher-order cognitive effort, such as problem-solving, controlling variables, and grappling with conceptual challenges. As Simanjuntak et al. (2022) note, when students find a lesson boring or unengaging, they may turn to cyberloafing (playing games, using social media, instant messaging) as an alternative source of stimulation.

It is precisely at this breaking point that the student’s response within an “Attitude-Self-Regulation-Risk” continuum comes into play. As discussed in Section 3.7, higher psychological resilience and dispositional hope are associated with lower problematic internet use (Yilmaz & Karaoglan Yilmaz, 2023). Within the S-DRW model, academic self-efficacy, emotion-regulation skills, and DSCTs are proposed as factors to be examined in relation to students’ goal-directed technology use in science laboratories; the role of ICT self-efficacy in reducing digital risks remains to be empirically tested.

5. The Science Education Digital Self-Regulation and Well-Being (S-DRW) Model

Risks such as problematic internet use and academic cyberloafing, as detailed in previous sections, suggest that relying solely on traditional restrictive approaches to integrating digital technologies into science education may be insufficient. In this context, there is a need for a unique framework that treats technology not merely as hardware but as a pedagogical ecosystem, and that can be directly integrated into science learning environments (laboratories, augmented reality applications, online simulations). In this section, by synthesizing current findings in the literature, the “Science Education Digital Self-Regulation and Well-Being (S-DRW) Model” is proposed as a conceptual framework intended to support students’ digital well-being during scientific inquiry processes. The model has not yet been empirically tested, and its multi-layered conceptual structure is presented in Figure 1.

Figure 1

The multi-layered S-DRW Model (the author's original conceptual synthesis), proposing how technology-related factors in science education may be organized to support students' digital well-being. The model is a literature-derived conceptual proposal and has not yet been empirically tested.

A Layered Model of Digital Well-Being in Science Education

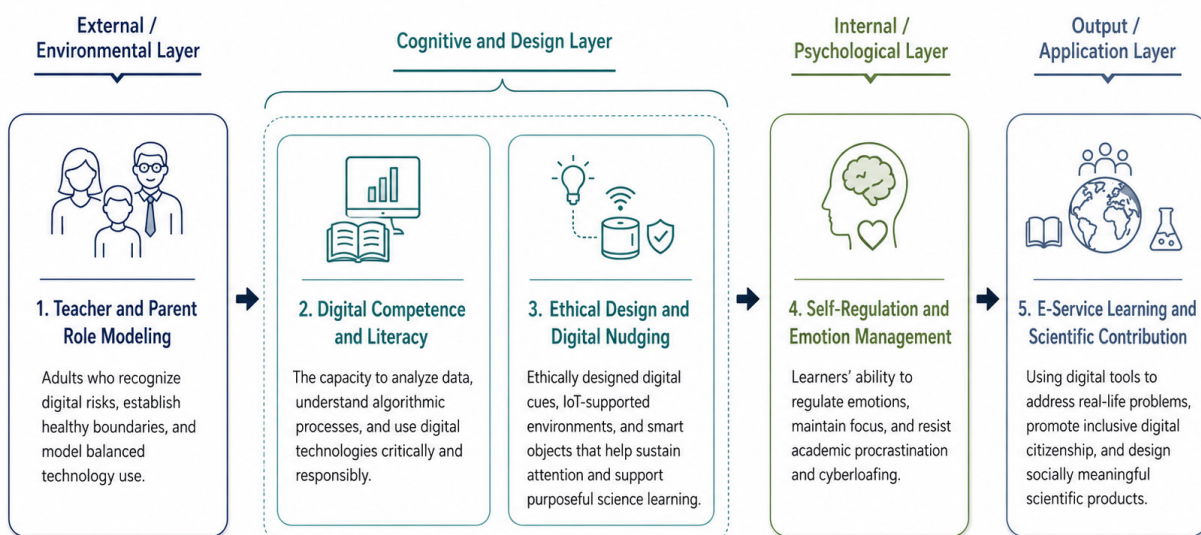


Figure 1 is an original conceptual synthesis developed by the author, integrating findings from the literature reviewed in this chapter. It has not been adapted from a previously published model or template. The five components are organized into four layers, moving from external/environmental supports toward outcomes: this left-to-right arrangement represents the conceptual organization of

the model and a suggested pedagogical sequence, not an empirically confirmed causal chain, and each proposed relationship remains to be tested in future research. Attitudes toward digital technologies, discussed throughout Section 4 and named in the chapter's title, are conceptually treated as an input to the Internal/Psychological Layer (Section 5.4), not as a separate box in the figure.

5.1. The Conceptual Basis of the S-DRW Model and the Teacher Factor

The S-DRW model proposes that supporting students' intrinsic autonomy, digital competence, and scientific curiosity may provide a more constructive approach than relying solely on external restrictions. Within the S-DRW model, teachers' digital well-being and their capacity to model balanced technology use are proposed as important external/environmental supports for students' digital self-regulation. In a study conducted on teacher candidates, it was found that candidates exhibited moderate levels of problematic internet use; specifically, male students and those who owned personal computers were found to be more prone to problematic internet use (Sirakaya & Seferoglu, 2013). Similarly, in a small exploratory study of 70 pre-service teachers, loneliness—but not locus of control, which was not significantly correlated with problematic internet use in that sample—was associated with problematic internet use (Liu & Masten, 2016). Consequently, the S-DRW model considers the ability of science teachers in their role as practitioners to manage their own digital risks and serve as “digital role models” for students to be one proposed component of the system.

At the family level, X. Li et al. (2013) found that parental behavioral control (e.g., restriction) and psychological control (e.g., love withdrawal) were associated with problematic internet use in opposite directions—behavioral control negatively, psychological control positively. Self-control fully mediated the restriction–PIU relationship and partially mediated the love-withdrawal–PIU relationship; a third psychological-control dimension tested in the same study, guilt induction, was not significantly associated with PIU. This differentiated finding underscores the importance of the “environmental/external layer” (the role of parents and teachers as models) in the S-DRW model, while cautioning against treating all forms of parental control as equivalent.

Conceptually, each layer of the S-DRW model is grounded in an existing theoretical or empirical strand of the literature synthesized in this chapter, not in new data collected for it. The External/Environmental Layer (Section 5.1) is informed by research documenting problematic internet-use patterns among pre-service teachers (Sirakaya & Seferoglu, 2013) and an association between loneliness and problematic internet use observed in a small exploratory sample of pre-service teachers (Liu & Masten, 2016). These findings provide a rationale for proposing teacher role modeling as a component of the framework, although the role-modeling pathway itself remains to be empirically tested. The Cognitive and Design Layer (Sections 5.2–5.3) draws on the digital-competency/digital-dependency distinction (Chen et al., 2025) and on digital-nudge design research (Al-Mansoori et al., 2023) and IoT-based design research (Gennari et al., 2023). The Internal/Psychological Layer (Section 5.4) draws on the self-regulation, self-control, and emotion-regulation research reviewed in Section 4. The Output/Application Layer (Section 5.5) draws on the e-service-learning and digital-ethics literature (Burr & Floridi, 2020; Culcasi et al., 2025). Because the model synthesizes findings from

separate studies that were not designed to test one another's relationships, the pathways connecting these layers are proposed, not confirmed. Testing them would require, for example, longitudinal or intervention studies examining the testable hypothesis that strengthening teachers' digital role-modeling (the External/Environmental Layer, Component 1) is associated with corresponding changes in students' self-regulation (the Internal/Psychological Layer, Component 4) and, in turn, with academic or well-being outcomes. In specifying such tests, science achievement and digital well-being should be treated as separate outcomes: appropriate indicators of science achievement include conceptual learning or research-task performance, whereas digital well-being is better indexed by well-being and daily-functioning measures than by screen time alone, which is not by itself a sufficient indicator of digital well-being.

5.2. The Cognitive Dimension of the Model: Digital Competence and Scientific Data Management

Science education requires students to access accurate scientific information amidst vast data sets in digital environments, analyze this information, and subject it to critical scrutiny. The cognitive dimension of the S-DRW model is built on the distinction between “digital dependency” and “digital competence.” A cross-sectional network analysis identified these as two distinct clusters, with emotional regulation emerging as the most central, bridging node—positively associated with adaptive (emotion-focused) coping within the digital-competency cluster and negatively associated with avoidant coping within the digital-dependency cluster. Because the design was cross-sectional, these should be read as associations and not confirmed causal effects (Chen et al., 2025). This distinction is critical in science education. Digital well-being is associated with digital literacy skills, which are important for school-age students to navigate complex digital environments safely and effectively (Arkan & Bal, 2025). Within this component, the S-DRW model proposes that a science student should not be a “consumer” of simulations, online experiments, or AI-supported databases, but a digitally literate person who understands the logic behind the algorithms he/she uses. As artificial intelligence and productivity tools become embedded in daily digital environments, their use should be accompanied by digital awareness, since such tools may themselves become sources of problematic engagement (Uslu, 2025).

5.3. Model Design Aspect: IoT and Digital Nudge in Science Laboratories

Features of digital environments associated with the “attention economy” may make sustained, goal-directed attention more difficult during class. To address this issue, the S-DRW model recommends that educational environments be organized according to the principles of “designing for digital wellbeing.” Al-Mansoori et al. (2023) highlight the importance of “soft nudges” and design improvements intended to positively influence user behavior. For example, design interventions that gently remind a student about a social media app running in the background while they are collecting data via a tablet in a science lab, or that help redirect their focus back to the experiment, serve as environmental enablers within the S-DRW model.

The model proposes the integration of interactive tools, such as the Internet of Things (IoT), as one possible way of promoting more active engagement with digital technologies in science education. In an exploratory design study conducted in a single high-school class, Gennari et al. (2023) engaged students in programming and testing IoT-based physical tools as a way of prompting reflection on digital well-being. Given the exploratory and context-specific design, these findings should not be interpreted as evidence of a general causal effect on students' digital well-being. Within the S-DRW model, phygital applications are proposed as one possible way to support active, goal-directed engagement and reduce opportunities for academic cyberloafing. This relationship has not yet been tested empirically.

5.4. The Internal/Psychological Dimension of the Model: Self-Regulation and Emotion Management

The fourth component of the S-DRW model corresponds to the Internal/Psychological Layer in Figure 1 and addresses learners' capacity to regulate their emotions, sustain attention, and resist academic procrastination and cyberloafing when using digital tools in science-learning contexts. As discussed in Section 4, self-regulation—understood here as the broader capacity to monitor and direct cognitive, emotional, and behavioral processes toward learning goals—together with its more specific subcomponents of self-control and emotion regulation, functions as the internal counterpart to the external and design-based supports described in Sections 5.1–5.3 (teacher/parent role modeling, digital competence, and ethically designed environments). Where those earlier components describe what surrounds the learner, this component describes what the learner must be able to do internally to translate those supports into sustained, goal-directed engagement with science learning.

Attitudes toward digital technologies and digital learning, discussed in Section 4.1, are treated in the S-DRW model as an input to this internal/psychological layer, not as a separate box in Figure 1. The model proposes that a student's attitudes shape the effort they are willing to invest in self-regulation, and that, in turn, successful self-regulation experiences reinforce more favorable attitudes toward using technology for learning — a reciprocal relationship the model puts forward for future testing rather than one that has been empirically confirmed. As discussed in Section 4.2, emotion regulation self-efficacy has been found to partially mediate the relationship between digital game addiction and academic motivation, with problematic internet use separately moderating that relationship (Celikkaleli et al., 2025); reappraisal-based emotion regulation has similarly been linked to lower internet-addiction scores at low-to-average usage levels (Şan et al., 2025).

5.5. The Output/Application Dimension of the Model: E-Service Learning and Scientific Contribution

The output-oriented component of the S-DRW model, following the internal/psychological layer described in Section 5.4, involves the student directing the scientific knowledge and digital competencies they have acquired toward a social benefit. The S-DRW model proposes that socially meaningful uses of technology may complement individual self-regulation by connecting digital

activity with contribution and engagement; this proposed pathway remains to be empirically tested. From an ethical perspective, digital technologies should be designed and used in ways that support human well-being and flourishing (Burr & Floridi, 2020).

One concrete educational application of this perspective is e-service learning: designing e-service learning projects that guide students toward responsible and inclusive digital practices has been proposed as a promising way to promote digital well-being (Culcasi et al., 2025). The S-DRW model proposes that science teachers organize digital campaigns (e.g., developing websites or data-mapping projects) to help students address real-life issues such as pollution, recycling, or energy conservation. Through such activities, students would apply digital tools toward solving a scientific problem and generating social value, as a proposed alternative to using those same tools for instant gratification (e.g., games, social media).

6. Conclusion

Digital technologies offer substantial opportunities for learning while also introducing psychosocial risks associated with problematic internet use (PIU). In the context of science education, this chapter conceptualizes digital well-being not merely as reduced time online, but as the capacity to use technology purposefully while maintaining cognitive, emotional, and social well-being.

From the literature reviewed in this chapter, problematic internet use emerges as a multiply determined phenomenon rather than one with a single cause: self-control has been consistently associated with problematic internet use across the studies reviewed in Section 4.2, while family-level factors such as parental control style are also associated with PIU (Section 5.1). As discussed in Section 3.7, evidence on well-being outcomes from the United States and Israel showed a country-specific rather than uniformly cross-cultural pattern (Olenik Shemesh et al., 2024), underscoring that findings from this literature should not be overgeneralized into claims of universality.

Across the cross-sectional studies reviewed in Section 4.2, emotion-regulation difficulties are associated with problematic technology use, whereas evidence concerning emotional intelligence is mixed (Evren et al., 2018; Karaer & Akdemir, 2019; Mascia et al., 2020). Individuals may be more likely to engage with technology impulsively when experiencing negative emotional states such as stress or loneliness, a pattern also consistent with the role of weak inhibitory control and impulsivity in problematic technology use more broadly (Billieux & Van der Linden, 2012). This pattern should be read as an association, not as evidence that emotion-regulation difficulty is a proven cause of that turn.

As discussed in Section 4.3, the shift to remote and online learning during the COVID-19 pandemic placed additional strain on students' self-regulation and digital well-being (Al Lily et al., 2020; Xie et al., 2020), though whether this produced lasting change in students' digital habits remains, as noted there, an open empirical question. In this context, research on Digital Self-Control Tools (DSCTs) suggests that these tools may support users' efforts to regulate digital media use, although the evidence base draws predominantly on university students, office workers, and technology-savvy

users, which may limit how broadly these findings generalize (Monge Roffarello & De Russis, 2023). Consequently, the design of technology for education should aim to move users from unconscious consumption toward “meaningful interaction.” The S-DRW model should therefore be interpreted as a literature-derived conceptual framework, not as an empirically validated intervention model. Its proposed relationships still require empirical testing.

Recommendations for Implementation

Based on the reviewed literature and the proposed S-DRW model, the following are proposed as pilot applications to be evaluated, rather than as confirmed interventions, for researchers and practitioners within the educational ecosystem:

- ***Renewing Pedagogical Design in Science Education:*** Technology should function as a complementary learning resource rather than as a competing source of distraction in science classrooms and laboratories. Pedagogical strategies involving digital nudging and applied e-service-learning projects could be piloted and evaluated within teachers’ lesson plans.
- ***Awareness Programs for Teachers and Parents:*** Considering documented associations between parental control patterns and problematic internet use, together with the teacher role-modeling component proposed in the S-DRW model, school guidance services may consider psychoeducational programs on digital parenting and emotion management for parents and teacher candidates.
- ***Supporting Emotion Regulation and Self-Regulation Skills:*** Schools could pilot and evaluate social-emotional learning (SEL) approaches aimed at supporting emotion regulation and self-regulation in relation to problematic technology use.

Recommendations for Future Research

Considering the gaps in the literature and the rapid pace of digital technologies, the following directions can be suggested for researchers:

- ***Long-Term Post-Pandemic Longitudinal Modeling:*** To examine the possible long-term changes in digital habits associated with the pandemic-era shift to remote learning, longitudinal studies should track variables such as loneliness, psychological well-being, and academic procrastination among adolescents and university students over time.
- ***Cross-Cultural and Comparative Studies:*** Problematic internet use and cyberbullying may vary across cultural and educational contexts. Therefore, cross-cultural analyses comparing the digital risk tendencies of students in Turkey with those of students in other countries across Asia and Europe with different educational and cultural contexts are needed.
- ***Methodologically Diverse Future Directions:*** Two distinct directions are recommended for future work. First, network-analytic and structural equation modeling (SEM/PLS-SEM) studies with

larger, more diverse samples are needed to further test the distinction between digital competence and digital dependency proposed in this chapter. Second, and separately—since network analysis and SEM are statistical, not artificial-intelligence, methods—artificial intelligence and machine-learning-based approaches could be explored to model individuals' behavioral traces in online environments and to support the early identification of at-risk usage patterns.

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