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Erika Maksniemi

Adolescents' socio-digital engagement, sleep, and academic well-being

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Abstract

This thesis examined adolescents' socio-digital engagement across the years of adolescence. The overall aim of this dissertation was to investigate the complex interplay between adolescent's socio-digital engagement and academic well-being while considering the role of sleep, a research area that has received less attention. The first aim was to examine how various types of socio-digital engagement are associated with sleep and academic well-being in different phases of adolescence considering both short- and long-term effects. The second goal was to investigate the potential moderating factors that explain individual differences in the associations between socio-digital engagement, sleep, and academic well-being. The third aim was to address various theoretical mechanisms and processes between various forms of socio-digital engagement and academic well-being. Previous studies, focusing solely on motivational aspects, have already identified some links between socio-digital engagement and academic well-being. However, this dissertation also emphasized mental energy depletion and sleep displacement processes.

Socio-digital engagement was mainly conceptualized as activities related to social media use (SMU) and conceptualized through usage motives (ie. friendship-driven SMU) or types (ie. active or passive SMU). The focus of this thesis was on friendship-driven socio-digital engagement. The conceptualization of academic well-being involved the concepts of school engagement and school burnout. Last, sleep was conceptualized through objective and self-reported bedtimes, along with self-reported sleep quality. This dissertation was multidisciplinary, and therefore the Differential Susceptibility to Media Effects model, Demands-Resources model, and Sleep displacement hypothesis as theoretical perspectives were adopted.

This thesis consists of four original studies. Study I was a cross-sectional survey study that examined how various socio-digital engagement types were associated with sleep quality, school burnout, and school engagement in early adolescence (at the age of 12–13 years). Study II was a follow-up survey study with a focus on longitudinal associations between active SMU, bedtimes, and academic well-being across the years of adolescence (from age 13–14 to age 18–19). Study II examined associations with yearly lags. Study III continued to examine the links between socio-digital engagement, sleep, and academic well-being, but focusing

on short-term effects by using an experience sampling method. Study III was conducted in late adolescence (at the age of 17–18 years), and it combined self-reported questionnaire data with ambulatory assessments of objective bedtimes. Furthermore, moderators that might explain individual differences in the daily associations were investigated. Study IV was a narrative review and addressed the complex interplay between socio-digital engagement and academic well-being. It focused on reviewing meta-analyses, reviews, and key studies and, as a result, introduced a new theoretical model: the Developmental-Contextual Digital Demands and Resources model.

Study I indicated that, in early adolescence, the associations between socio-digital engagement, sleep, and academic well-being differed by gender. Girl's friendship-driven and entertainment-driven socio-digital engagement associated with worse academic well-being, while boys', digital gaming had a similar effect. Study II indicated that associations between active SMU (driven by friendship motives), bedtime, and academic well-being varied across different phases of adolescence. Active SMU associated with later bedtimes, especially in early adolescence, and it was associated with emotional exhaustion related to schoolwork in middle and late adolescence. Finally, Study III indicated that, in late adolescence, friendship-driven socio-digital engagement (with the motive of connecting with friends) in the evening was not detrimental to same-night sleep or to the following day's tiredness, stress and anxiety during school days. However, adolescents who felt pressure to remain constantly available online and found it stressful tended to have later bedtimes and higher levels of tiredness, stress, and anxiety during school days. This indicated that the experiences related to socio-digital demands may have negative effects on adolescent sleep and academic well-being. The Developmental-Contextual Digital Demands and Resources model (Study IV) emphasized the existence of two overlapping processes, i.e., the energy-depleting and the motivational process, through which individual differences in the associations between socio-digital engagement and academic well-being can be conceptualized.

In conclusion, this dissertation found that the associations between socio-digital engagement, sleep, and academic well-being vary at different developmental phases during adolescence. Early adolescence may experience more sleep disruption due to friendship-driven socio-digital engagement, while late adolescence sees associations with energy depletion. These findings emphasize the importance of adolescents developing socio-emotional and self-regulation skills to manage the challenges posed by common socio-digital practices. These skills could explain individual variations in how socio-digital media affects adolescents.

Keywords: socio-digital engagement, sleep, academic well-being, adolescence

Helsingin yliopisto, Kasvatustieteellinen tiedekunta
Kasvatustieteellisiä tutkimuksia, numero 173

Erika Maksniemi

Nuorten sosio-digitaalinen osallistuminen, uni ja kouluhyvinvointi

Tiivistelmä

Tämä väitöskirja tarkasteli erilaisia sosio-digitaalisen osallistumisen muotoja murrosiän aikana. Tutkimuksen kokonaisvaltainen tavoite oli tutkia nuorten sosio-digitaalisen osallistumisen monimuotoisia yhteyksiä kouluhyvinvointiin ottaen huomioon unen rooli, mikä on saanut vähemmän huomiota aiemmissa tutkimuksissa. Ensimmäinen tavoite oli selvittää, miten erilaiset sosio-digitaalisen osallistumisen muodot ovat yhteydessä uneen ja kouluhyvinvointiin murrosiän eri vaiheissa huomioiden sekä lyhyen että pitkän aikavälin vaikutukset. Toiseksi tutkittiin tekijöitä, jotka selittävät yksilöllisiä eroja sosio-digitaalisen osallistumisen, unen ja kouluhyvinvoinnin välillä. Kolmanneksi käsiteltiin erilaisia teoreettisia mekanismeja ja prosesseja erilaisten sosio-digitaalisen osallistumisen muotojen ja kouluhyvinvoinnin välillä. Aikaisemmat tutkimukset ovat havainneet yhteyksiä sosio-digitaalisen osallistumisen sekä kouluhyvinvoinnin välillä, selittäen niitä lähinnä motivationaalisten tekijöiden avulla. Tämä väitöskirja keskittyi myös prosesseihin, jotka liittyvät nukkumaanmenoajan myöhästymiseen tai heikompaan unenlaatuun, väsymykseen, uupumukseen sekä liiallisiin vaatimuksiin.

Sosio-digitaalinen osallistuminen käsitteellistettiin sosiaalisen median käytön ja digitaalisen pelaamisen kautta, sekä käyttötarkoitusten (esim. kaverilähtöinen sosiaalisen media käyttö) tai käyttötyypin (aktiivinen tai passiivinen sosiaalisen media käyttö) kautta. Tässä väitöskirjassa keskityttiin kaverilähtöiseen sosio-digitaaliseen osallistumiseen. Kouluhyvinvointi käsitteellistettiin koulu-uupumuksen ja kouluinnon sekä koulupäivän aikaisten tilannekohtaisten väsymyksen, stressin ja ahdistuksen tunteiden kautta. Unta tarkasteltiin nukkumaanmenoaikojen ja unen laadun kautta. Tämä väitöskirja oli monitieteellinen, ja sen teoreettisinä lähtökohtina hyödynnettiin Differential Susceptibility to Media Effects -mallia, Demands-Resources -mallia ja Sleep displacement -hypoteesia.

Tämä väitöskirja koostuu neljästä osatutkimuksesta. Osatutkimus I oli poikkileikkaustutkimus, jossa tutkittiin erilaisten sosio-digitaalisen osallistumisen tapojen yhteyksiä nuorten unen laatuun, koulu-uupumukseen ja kouluintoon 12–13-vuotiailla. Osatutkimus II oli jatkotutkimus, ja siinä keskityttiin pitkittäisiin yhteyksiin aktiivisen sosiaalisen media käytön, nukkumaanmenoaikojen ja kouluun liittyvän emotionaalisen uupumuksen välillä seuraamalla nuoria 13–14-vuotiaasta 18–19-vuotiaaksi. Osatutkimus III jatkoi sosiaalisen median käytön, unen ja kouluhyvinvoinnin yhteyksien tutkimista, mutta keskittyi lyhyen aikavälin vaikutuksiin käyttäen kokemusotantamenetelmää, jonka aikana nukkumaanmenoaikoja

mitattiin objektiivisesti. Osatutkimus III toteutettiin 17–18-vuotiailla ja siinä yhdistettiin itseraportoituja vastauksia objektiivisesti kerättyihin nukkumaanmenoaikoihin. Lisäksi tutkittiin muuttujia, jotka selittivät päiväkohtaisia yhteyksiä sosiaalisen media käytön, unen ja kouluhyvinvoinnin välillä. Osatutkimus IV oli kirjallisuuskatsaus, jossa tarkasteltiin sosio-digitaalisen osallistumisen ja kouluhyvinvoinnin välisiä teoreettisia ja empiiriä yhteyksiä. Kirjallisuuskatsaus tarkasteli aiempia meta-analyyseja, systemaattisia kirjallisuuskatsauksia sekä keskeisiä empiirisiä tutkimuksia, joiden pohjalta esiteltiin uusi teoreettinen malli, Developmental-Contextual Digital Demands and Resources malli.

Osatutkimus I osoitti, että erilaiset yhteydet sosio-digitaalisen osallistumisen, unen ja kouluhyvinvoinnin välillä vaihtelivat tyttöjen ja poikien kesken. Tyttöjen kohdalla kaverilähtöinen ja viihdelähtöinen sosio-digitaalinen osallistuminen liittyi heikompaan kouluhyvinvointiin, kun taas poikien kohdalla digitaalinen pelaaminen liittyi heikompaan kouluhyvinvointiin. Unen laatu välitti joitain yhteyksiä sosio-digitaalisen osallistumisen ja kouluhyvinvoinnin välillä, mutta ne vaihtelivat poikien ja tyttöjen välillä. Osatutkimus II osoitti, että aktiivisen sosiaalisen median (jonka tarkoituksena oli kavereiden kanssa vuorovaikuttaminen ja sosiaaliset suhteet), kouluhyvinvoinnin ja nukkumaanmenoaikojen väliset yhteydet vaihtelivat murrosiän eri vuosien aikana. Tulokset viittasivat siihen, että lisääntynyt aktiivinen sosiaalisen media käyttö oli yhteydessä tavallista myöhäisempään nukkumaanmenoajankohtaan erityisesti 13–14-vuotiailla, ja lisääntynyt aktiivinen sosiaalisen median käyttö oli yhteydessä lisääntyneeseen emotionaaliseen uupumukseen murrosiän keski- ja myöhäisvaiheissa (14–15-vuotiaat ja 17–18-vuotiaat). Viimeisenä, osatutkimus III antoi viitteitä siitä, että sosio-digitaalinen osallistuminen, jonka motiivina on yhteydenpito ystäviin, ei ole haitallista nuorten unelle tai kouluhyvinvoinnille 17–18-vuotiailla lukiolaisilla. Osatutkimuksessa III kuitenkin havaittiin, että stressin tunteet, jotka liittyvät jatkuvasti tavoitettavissa olemiseen puhelimen kautta, olivat yhteydessä väsymykseen, stressiin ja ahdistukseen sekä myöhempiin nukkumaanmenoaikoihin ja heikompaan unenlaatuun. Developmental-Contextual Digital Demands and Resources -malli (Osatutkimus IV) korosti, että on olemassa kaksi limittyvää prosessia, energiaa kuluttava vaatimusprosessi sekä motivaatioon liittyvä prosessi, joiden kautta yksilölliset erot sosio-digitaalisen osallistumisen ja kouluhyvinvoinnin välillä voidaan käsitteellistää.

Tämä väitöskirja osoitti, että yhteydet sosio-digitaalisen osallistumisen, unen ja kouluhyvinvoinnin välillä vaihtelevat eri ikäisillä nuorilla. Erityisesti, murrosiän alussa kaverilähtöinen sosio-digitaalinen osallistuminen voi linkittyä heikentyneeseen uneen. Myöhemmin nuoruudessa vastaavanlainen toiminta voi olla yhteydessä uupumukseen ilman, että se vaikuttaa negatiivisesti uneen. Tulosten perusteella voidaan todeta, että nuorilla on tarve henkilökohtaisille voimavaroille ja taidoille selviytyäkseen erilaisista sosio-digitaaliseen osallistumiseen liittyvistä

sosiaalista paineista ja vaatimuksista. Nämä taidot ovat sosioemotionaalisia ja liittyvät itsesäätelyyn. Näitä taitoja vahvistamalla voidaan tukea nuoria ja ennaltaehkäistä digitaalisen median negatiivisia vaikutuksia.

Avainsanat: sosio-digitaalinen osallistuminen, uni, kouluhyvinvointi, murrosikä

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I am delighted to find myself in the final phase of my PhD journey. At this moment, I am grateful for the chance to express my appreciation to the many people who have supported me along the way. Without their help, support, and guidance, my work would not be where it is today. Most importantly, without these people, this journey would not have been as fun, enjoyable, and meaningful as it has been.

First, I wish to convey my deepest gratitude to my three supervisors. Each of them has contributed, in many various ways, to my growth as a young scholar. I want to start by acknowledging my main supervisor, Professor Katariina Salmela-Aro. Her academic achievements, expanding list of publications, and international networks have greatly influenced my own academic path. Having such a respected professor as my supervisor fills me with pride, and I am thankful to you Kata for your consistent support and guidance throughout this process. Working with you has been a pleasure. I also extend my thanks to my supervisor, Professor Kirsti Lonka. Beyond your contributions to my development as a scholar, Kirsti, you have shared invaluable tacit knowledge, which I consider essential. I am grateful for the enjoyable and meaningful moments we have shared over the years. I highly appreciate your commitment to building the educational psychology community, which has also influenced my academic path. Dr. Elina Ketonen, as my supervisor, has served as an invaluable role model and support. I deeply appreciate your help, Elli, during these years. Thank you for being such an exceptional teacher by asking the right questions at the right time. I see you as a pioneer in our community, and it has been a privilege to follow your example. With you Kata, Kirsti, and Elli, my remarkable supervisors, we created a team where mutual respect has been the foundation. I see this as a very valuable factor that has supported my PhD work. Thank you for allowing me to work in my own way, offering just the right balance of support and autonomy.

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My path as a researcher began back in the autumn of 2011, even though I was not fully aware of it at the time. It all started with my bachelor studies in educational psychology and my involvement in the 'Noste' study group. Over more than three years, this group taught me about collaborative learning, persistence, mutual respect, and the joy of inquiry-based learning. To all the members of Noste, I am grateful for the valuable memories we have created, and I hope you remain an integral part of my future journey as well. During my bachelor studies, I also became actively involved in student organizations, notably the 'Lälää' group. I am very happy we became friends during those years. I must acknowledge that the skills I was able to develop together with you have played a significant role in my PhD work.

It is evident that a PhD journey does not occur in an academic vacuum. I have been fortunate to have many remarkable people outside of academia who have been essential to me. Each of them has contributed in their unique way. I would like to start by thanking all my closest friends, Heidi, Jannina, Linda, Milka, Saara, and Suvi (in alphabetical order), for adding purpose to my life in numerous ways. You are a larger resource in my academic work than you might even understand. Having each of you present in my life means a lot to me. I am so happy to have such amazing people in my life who make me laugh, who have strong opinions that I can learn from, and who are there for me through the good and bad days.

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Nummela, 25.10.2023
Erika Maksniemi

Contents

List of original publications

This dissertation is based on the following four original publications, which are referred to in the text by their Roman numerals (Studies I-IV):

Study I
Maksniemi, E., Hietajärvi, L., Lonka, K., Marttinen, E., & Salmela-Aro, K. (2018). Sosiodigitaalisen osallistumisen, unenlaadun ja kouluhyvinvoinnin väliset yhteydet kuudesluokkalaisilla. *Psykologia*, *53*(2-3), 180–200.

Study II
Maksniemi, E., Hietajärvi, L., Ketonen, E. E., Lonka, K., Puukko, K., & Salmela-Aro, K. (2022). Intraindividual associations between active social media use, exhaustion, and bedtime vary according to age – A longitudinal study across adolescence. *Journal of Adolescence, 94*(3), 401–414. DOI: https://doi.org/10.1002/jad.12033

Study III
Maksniemi, E., Ketonen, E.E., Salonen, V., Lonka, K. & Salmela-Aro, K. (submitted). Social media use may not be that harmful for late adolescents' sleep and the following day school wellbeing - an experience sampling study. DOI: 10.31234/osf.io/skdf2

Study IV
Hietajärvi, L.*, Maksniemi, E.*, & Salmela-Aro, K. (2022). Digital engagement and academic functioning. *European Psychologist*, *27*(2). DOI: https://doi.org/10.1027/1016-9040/a000480
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1 Introduction

During the past decade, two trends have developed simultaneously among adolescents: mental health problems and time spent online (Cosma et al., 2020; Orben & Blakemore, 2023). This has raised concerns among researchers and the general public regarding the causal trends between increasing time spent online and well-being (see for example Twenge et al., 2018). School-related burnout, which is an important well-being dimension in adolescence, has also been on the rise in Finland in the 2010s (Read et al., 2022). Relatedly, schoolwork pressure has increased, especially in high-income countries like Finland (Cosma et al., 2020). However, empirical evidence has been unable to show convincing evidence that the time adolescents spend online is a strong contributor to lower well-being (eg. Appel et al., 2020; Keles et al., 2019; Odgers & Jensen, 2020; Vuorre & Przybylski, 2023, preprint) or that it negatively influences how adolescents perform at school (e.g., Adelantado-Renau et al., 2019). However, researchers have typically conceptualized online engagement as simply the overall time adolescents spend online, thereby overlooking the various ways and motivations that form the online activities. There is no doubt that the Internet provides adolescents with multiple opportunities, such as communicating with peers and parents, entertainment, or information for schoolwork (Allen et al., 2014; Lenhart, 2015). Despite these positive consequences of using digital technologies, the public perspective has focused more on the potential harms than the benefits (Haddock et al., 2022). This has led to the creation of a new wave of "moral panic", which often happens with new technologies (Orben, 2020a).

Researchers have therefore moved forward and begun searching for evidence from wider concepts than solely time spent online, such as the type of online content and motives for usage. In line, in this dissertation, I refer to socio-digital engagement as a broad concept of online practices, which are not dependent on specific technological device, platform, or tool. Socio-digital engagement refers to the use of digital technologies for social interaction and communication, such as social media platforms, instant messaging, and online gaming. This has led to more nuances and the complexity of online behavior among youths, and the consequences of various digital engagement forms are acknowledged to a higher degree (Johannes et al., 2022; Vuorre et al., 2022, preprint). One main viewpoint is that engaging online does not affect all individuals in the same way, even if adolescents were to spend the same amount of time engaging with the same content in the same digital platform (Piotrowski & Valkenburg, 2015). This means that individuals have different susceptibilities related to the effects of socio-digital engagement. Adolescents differ in how they are affected by their online engagement

and how each individual's pre-existing conditions, developmental stage, and individual characteristics form their behavior online (Valkenburg & Peter, 2013).

That said, socio-digital engagement rarely either decreases or increases the various dimensions of well-being within the same individual, but rather causes both responses simultaneously (Valkenburg, 2022; Weinstein, 2018). In addition, how individuals engage online plays a large role (Dienlin & Johannes, 2022). A meta-analysis conducted by Hancock et al. (2022) and a large-scale study conducted by Vuorre and Przybylski (2023, preprint) suggest that engaging online is generally not strongly associated with lower psychological well-being. However, psychological well-being is multifaceted and consist of various domains; therefore, socio-digital engagement can influence the well-being domains in different ways. For instance, previous research (Salmela-Aro et al., 2017) reported a reciprocal association between socio-digital engagement and school burnout. However, Puukko et al. (2020) demonstrated that depressive symptoms predicted an increase in socio-digital engagement, but no evidence of a reverse association was found. This suggests that certain aspects of psychological well-being can act as either a cause or an outcome, and socio-digital engagement can also serve as a symptom of lower psychological well-being. In other words, the mechanisms underlying the observed relationships vary. Related to this, the effects of socio-digital engagement on various well-being domains needs to be separated into short-term and long-term effects (Dienlin & Johannes, 2022). Short-term effects refer to, for example, how socio-digital engagement is associated with tiredness during a school day. Long-term effects refer to, for example, how socio-digital engagement is associated with domains that develop over a longer period, such as symptoms of school burnout (Dienlin & Johannes, 2022; Hancock et al., 2022).

This dissertation therefore focuses on these complex nuances considering developmental aspects and the various forms of socio-digital engagement and examines both the long- and short-term effects. Specifically, the focus is on friendship-driven socio-digital engagement, sleep during school days, and well-being in the school context, to which I refer to as academic well-being. Only a limited number of studies have focused on socio-digital engagement, sleep, and academic well-being throughout the years of adolescence.

1.1 Adolescents in the digital world

In Finland, adolescents have access to the Internet everywhere they go, and social media features are an important component of modern daily life, especially for youths. Based on annual Official Statistics of Finland (2021), 98% of youths between the ages of 16 and–24 use the Internet several times a day and use mobile

phones for Internet access. The majority report communication via phone (94%), watching videos (98%), listening to music (97%), and following various social media channels (94%). In 2020, Instagram and WhatsApp were the most popular social media platforms among Finnish youths aged 16–24, while Snapchat, Facebook, and TikTok were also popular services, and 89% of the age group report following one of these at least once a day. Based on the EU Kids Online 2020 study (Smahel et al., 2020), the activities adolescents engage in online are similar in other EU countries. According to a Pew Research Center report (Vogels et al., 2022), half of U.S. adolescents report using social media platforms almost constantly. They additionally report that the time spent on social media is excessive (31% of boys, 41% of girls) but also that it would be hard (49% of boys, 58% of girls) to give up using it (Vogels et al., 2022).

During the 21st century, socio-digital engagement is suggested to have become necessary for youths to accomplish key developmental tasks related to social connections with peers and to personal identity formation (Haddock et al., 2022; Parent, 2023), and adolescents perceive it as part of their daily lives and as having a positive influence on various domains of their development (Fitton et al., 2013). Social media helps to accomplish some of the key developmental tasks in adolescence. For example, being in contact with friends online offers more time for controlling what to express and how to express oneself (Scott et al., 2022) and can increase an individual's feelings of relatedness (Parent, 2023). Social media can also help maintain connection with close friends (Reich et al., 2012), which is important during adolescence (Raboteg-Saric et al., 2014). On the other hand, permanent and constant access to online environments can change the cognitive structures of adolescent minds and create a mindset that is permanently and nearly constantly online (Klimmt et al., 2018). This can further develop new habits (such as allowing smartphones to interrupt sleep) because adolescents are bonded with their smartphones (Vorderer et al., 2016).

This dissertation focuses on the sensitive period of adolescence. Adolescence is characterized by many psychological changes linked to social and cognitive maturity, but how "stormy" this period is varies between individuals (Eccles et al., 2003). Adolescence is a transition from childhood to the attainment of emerging adulthood, and this transition usually begins at the age of 10–12 years and lasts until the age of 24 or 25 (Dahl et al., 2018). This dissertation focuses on adolescents aged 12 to 19. More specifically, early adolescence refers to the age range of 12 to 14 years, middle adolescence refers to the age range of 14 to 16 years, and late adolescence refers to the age range of 16 to 19 years. Adolescence is a period when making social connections with peers is highly important, peer networks expand, and peers become the primary sources of social support (Núñez-Regueiro & Núñez-Regueiro, 2021; Sawyer et al., 2012). Adolescents derive many of their (digital) practices from their peers (Eccles et al., 2003; Livingstone

& Haddon, 2012; Masten & Motti-Stefanidi, 2020), and, at this age, social connections are developed and maintained widely through social media (Lenhart et al., 2015; Science Advice Initiative of Finland, 2021). During this life phase, individuals are especially susceptible to peer influence because they aim to avoid social exclusion and rejection (Blakemore, 2018). Indeed, social media has shaped adolescents' peer experiences, e.g., by amplifying social demands or urging the immediacy of interactions (Nesi et al., 2018). Though social media has a positive impact on social-emotional domains of life (Haddock et al., 2022), such as friendship closeness (Pouwels et al., 2021a), adolescents' readiness to regulate their personal self-control may be limited (Casey & Caudle, 2013). This may influence the frequency and ways in which adolescents engage on social media platforms and services (Coyne et al., 2019; Siebers et al., 2022b).

This dissertation investigates the effects of socio-digital engagement on sleep and academic well-being among individuals born in the 2000s. These adolescents have been referred to as the iGen (Twenge, 2020), a generation born in the mid-1990s up to the mid-2000s. These so-called "digital natives" engage in an ever-changing digital ecosystem that is enhanced by mobile media from their very infancy (Bennett & Maton, 2010). This generation was born when social media and mobile phones already existed, therefore they do not remember a time without constant Internet access and connections to others. However, this generation is not uniform, meaning that individuals can differ highly in how and why they engage in the digital world (Bennett & Maton, 2010; Evans & Robertson, 2020; Haddon et al., 2020; Valkenburg & Peter, 2013) and how this engagement explains various well-being domains in the "offline world", i.e., socio-digital engagement effects.

1.1.1 Socio-digital engagement

Time spent online is not a sufficient measure for detecting fluctuations in well-being, but distinguishing between the types of socio-digital engagement can bring out various effects on adolescent well-being (Course-Choi & Hammond, 2020). In this dissertation, I emphasize informal socio-digital engagement that occurs outside the school context. This means that I am not placing emphasis on socio-digital engagement associated with studying or completing homework, but rather on socio-digital engagement centered around online social interactions with friends and participation in social media. These activities commonly happen during adolescent free time (e.g., at home after school, during hobbies, or during school breaks).

Social media use on various social media platforms in general refers to online activities that foster user-generated content creation and sharing and allows users to interact with each other (Kaye, 2021). The term social media refers to Internet-based networks that enable users to interact with others both verbally and visually

(Carr & Hayes, 2015). I refer to social media use as a form of socio-digital engagement that occurs on various social media platforms that are common among adolescents (eg. Instagram, Snapchat, TikTok, YouTube). Furthermore, in this thesis, social media use is regarded as an activity driven by the motivation to sustain social connections. These practices and behaviors on various social media platforms are social in nature and have been conceptualized in multiple ways in the literature. One popular analytical manner of distinguishing between social media use types is to separate active and passive usage (see for example Verduyn et al., 2017). However, the dichotomy between active and passive is rare, as both active and passive usage have multiple subcategories (Meier & Reinecke, 2021). Active usage targets interactions occuring between users and can be categorized based on the direction of the interaction: one-way non-interactive sending, two-way reactive engagement, or two-way interactive engagement (Meier & Reinecke, 2021). Passive social media use is more concerned with browsing content produced by others without strong social connections (Beyens et al., 2020; Valkenburg et al., 2022a) and is more one-way and non-interactive in nature (Kaye, 2021; Meier & Reinecke, 2021). Passive social media use is associated more with amusement and entertainment (Weinstein, 2018) while active social media use is more linked to social connections (Verduyn et al., 2017). Ito et al. (2010) have categorized socio-digital engagement based on usage motivation: either friendship-driven or interest-driven. Friendship-driven activities refer to using technologies to keep up and deepen social connections with others and interest-driven activities refer to utilizing modern technologies to learn and engage in activities that are of interest. Combining these concepts means that adolescents who engage in active or passive social media use can have different motivations.

Apart from the active or passive categorization, social media usage can also be examined from the perspective of privacy or publicity. For example, private active social media use means that messages are being sent privately, whereas public active social media use means that an individual is commenting on open posts. Overall, private social media use is more common, more synchronous, and more intimate (Valkenburg et al., 2022b); thus, it may show stronger effects with adolescents' psychosocial well-being. Recent reviews, however, have challenged these assumptions on active and passive social media use and their positive or negative effects on well-being (Meier & Krause, 2022; Valkenburg et al., 2022a). That said, the effects of socio-digital engagement on various domains of adolescent life are complex.

1.1.2 Social pressure to remain accessible

Research concerning the effects of socio-digital engagement on adolescent well-being has focused on behavioral components (e.g., how time spent online affects

adolescent well-being). This approach neglects that individuals are constantly connected with each other psychosocially through social media (Johannes et al., 2021b; Klimmt et al., 2018). Thus, measures that dichotomize socio-digital engagement into active or passive or focus on usage motives do not reveal the whole picture. Measures of socio-digital engagement that emphasize other dimensions, such as how social media use is perceived, are important when investigating the individual differences in how socio-digital engagement affects adolescent well-being (Steele et al., 2020).

In addition to behavioral components, this dissertation focuses on psychosocial dimensions through the concept of experienced social pressure of constantly remaining available to others online. Some studies have indicated that this pressure of remain available online is nowadays normative, but adolescents still feel that constant availability creates feelings of stress (MacKenzie et al., 2022; Winstone et al., 2022). Concurrently, being in contact with friends can reduce stress (Yau et al., 2021). The connections individuals have on their phones are hybrid in the sense that it is hard to distinguish between offline and online relationships (Mihailidis, 2014). However, the need to rely on and get support from peers is a strong motivator for socio-digital engagement. From the developmental perspective, social pressure plays a central role, especially among adolescents because the need to belong to a group and the need to be accepted by peers is typical at this age (Parent, 2023).

Individuals differ in how they perceive such constant availability pressure (Steele et al., 2020), and expectations of constant availability are not only functions of social media but are also tied up with socially constructed norms or expectations (Klimmt et al., 2018; Steele et al., 2020). A study suggests that the longer individuals are apart from their smartphones (and social networks), the more pressing the feelings of availability demands become (Heitmayer & Lahlou, 2021). This may further develop the habits of constantly checking phone notifications and updates and of remaining online throughout the day. This type of social pressure can also decrease an individual's ability to control their socio-digital engagement (Halfmann & Rieger, 2019).

Reseachers have conceptualized the perceived demand of being constantly available online as availability stress, which is proposed as one dimension of overall digital stress (Steele et al., 2020). Digital stress, also referred to as technostress, is a multidimensional psychosocial concept consisting of connection overload, fear of missing out, approval anxiety, and availability stress (Steele et al., 2020). Digital stress is characterized as the stress arising from a prolonged and constant use of digital media triggered by permanent access to the endless supply and diversity of social content (Hefner and Vorderer, 2016). In the digital world, social stressors can, for example, be messages from friends or notifications from social media platforms indicating that someone has just updated content. Stress reactions on the other hand are physiological, affective, or behavioral — and the reactions

can be long or short term (Sonnentag & Frese, 2013). Digital stress is associated with lower subjective mental health (Hall, 2017; Nick et al., 2022; Steele et al., 2020).

Research on the "always-on" culture or the psychosocial dimensions of socio-digital engagement can reveal various effects on well-being and explain the differences between individuals (Meier & Johnson, 2022; Meier & Krause, 2022). For example, a recent quantitative study, with log data from mobile phones, showed that perceived online vigilance (whether thoughts related to constant smartphone use were negative or positive) was more important to daily affective well-being than smartphone use itself (Johannes et al., 2021b). In the adult population, the cognitive vigilance or salience of online communication was related to overall stress (Freytag et al., 2021). The link between mobile phone use and later mental health symptoms was greatest among young adults, who perceived more stress related to social availability demands (Thomée et al., 2011). Interestingly, such perceived availability stress is not strongly associated with the frequency of mobile phone use (Hall, 2017; Thomée et al., 2011). Contrary, higher expectations towards the online accessibility of an individual's friends is associated with using social media more (Siebers et al., 2022a).

1.2 Effects of socio-digital engagement on well-being

Average associations between time spent online and well-being are small or even nonexistent (Odgers & Jensen, 2020; Orben, 2020; Plackett et al., 2023; Stiglic & Viner, 2019). In many studies, technology use is not associated with adolescents' elevated mental health symptoms (e.g., Engberg et al., 2022; Jensen et al., 2019; Puukko et al., 2020). However, differences exist in the effects between individuals depending on gender, age, and the type of or motive for socio-digital engagement (Birgisson et al., 2023; Sheldon & Titova, 2023; Valkenburg & Peter, 2013), and there may be multiple moderators that influence the link between socio-digital engagement and well-being (Johannes et al., 2021a). In addition, the links can be bidirectional, which means that psychological well-being can equally well predict socio-digital engagement (Coyne et al., 2020; Puukko et al., 2020).

Active friendship-driven social media use may have the potential to enhance well-being through social connectedness (Appel et al., 2020; Orben, 2020; Verduyn et al., 2017), but active social media use has also been associated with increased feelings of disconnection or isolation (Weinstein, 2018). On the other hand, some studies report that active and friendship-driven social media use is not a major negative contributor to adolescents' psychological well-being (Verbeij et al., 2022, preprint). On the other hand, passive social media use (i.e., browsing on Instagram) has been associated with lower affective well-being and is especially harmful if adolescents experience negative social comparison (Weinstein, 2017).

In line, Verduyn et al. (2022) have proposed that passive social media use associates with lower subjective well-being through negative social comparison. Similarly, Thorisdottir et al. (2019) found that passive social media use was associated with greater symptoms of anxiety and depressed mood even after controlling for relevant risk and protective factors (i.e., self-esteem and offline peer support). Contrary, Boer et al. (2022) reported that passive and active social media use did not show differing effects on life satisfaction.

However, individuals shape their own media effects for better and for worse, meaning that, depending on the individual, the effects of socio-digital engagement can flip into negative or positive well-being effects (Meier & Johnson, 2022; Meier & Krause, 2022; Valkenburg & Peter, 2013). Even prior to modern technologies, media researchers confounded that television viewing was harmful, beneficial, or neutral to children (Valkenburg, 2015), depeding on the conditions. Media effects result from a complex and intertwined set of dispositional, developmental, and social influences. Therefore, empirical studies that have mainly focused on investigating direct and linear links between various forms of socio-digital engagement and well-being report contradictory results.

Several theoretical models have been proposed that underline differential susceptibilities and aim to identify the mechanisms for why some individuals are more susceptible to socio-digital engagement effects than others and how and why socio-digital engagement influences these individuals (Valkenburg et al., 2016). One of these, the Differential Susceptibility to Media Effects Model (DSMM), was adopted as one of the main theoretical tools in this thesis. DSMM underlies that media effects differ between individuals, and its focus is on micro-level media effects (Valkenburg & Peter, 2013). That is, the differences in media effects occur due to various developmental dispositions and goals, along with individual psychological conditions and social contexts that influence the associations (Valkenburg & Peter, 2013).

Despite its theoretical importance, a limited number of studies have focused on the developmental differences in the socio-digital engagement effects during the adolescent years (Orben & Blakemore, 2023). Orben et al. (2022), however, showed that, for girls, a window of sensitivity for experiencing negative social media effects was between the ages of 11 and 13 years, which meant that increases in social media use at this age predicted decreases in life satisfaction one year later. For boys, a similar window was observed between the ages of 14 and 15. In line, a study conducted with Finnish adolescents (age range of 11–15-year-olds) showed differences between the genders and that adolescents in different age groups showed various motives for socio-digital engagement (Lahti et al., 2021). Boys were more likely to report interest-driven socio-digital engagement, and adolescents who mentioned it were more likely to report lower academic achievement. Friendship-driven socio-digital engagement was more common among girls aged 13 and 15 with higher peer and family support (Lahti et al., 2021). In line,

Booker et al., (2018) reported that the associations between time spent on social media and lower emotional well-being were stronger among girls, especially in the early stage of adolescence, compared to boys.

The effects of socio-digital engagement on adolescent well-being have mainly been studied by emphasizing long-term effects, however, often without longitudinal study designs (Dienlin & Johannes, 2022). Thus, also the associations have mainly been investigated as between-person effects. This refers to studies that investigate whether those who use social media more differ from those who use it less (see for example Hisler et al., 2020). However, the effects of socio-digital engagement occur on the individual level (Valkenburg & Peter, 2013). Studies investigating the individual level focus on, for example, whether above-average social media use is associated with changes in a person's well-being (see e.g., Puukko et al., 2020; Orben et al., 2022). For instance, Beyens et al. (2020) showed that the effects of passive social media use on momentary affective well-being varied between adolescents and that the various types of social media use rarely yielded different effects within the same adolescent. Marciano et al. (2022) reported results from an experience sampling study, where participants' more frequent smartphone use was associated with higher levels of feeling better on that particular day. Nevertheless, the observed positive and negative consequences of socio-digital engagement depend on the dimensions of well-being and on whether the associations focus on between-individual or within-individual associations, and the long- and short-term effects may show very different results.

1.2.1 Socio-digital engagement and academic wellbeing

Research exploring the relationship between socio-digital engagement and academic well-being has not received as much focus as studies investigating the broader associations between socio-digital engagement and psychological well-being (Meier et al., 2020). School-related well-being is a multidimensional concept entangled with other dimensions of adolescent well-being (Cosma et al., 2020; Kiuru et al., 2019) and academic achievement (Kaya & Erdem, 2021) and can have wider and long-lasting effects on psychological well-being in general (Salmela-Aro et al., 2009b; Salmela-Aro & Upadyaya, 2014; Upadyaya & Salmela-Aro, 2013). Therefore, school provides an important context for adolescent psychosocial health and development (Eccles & Roeser, 2011; Eccles, 2004). Differences in academic well-being occur between individuals, but less variation is observed within individuals across the years of adolescence (Morinaj & Held, 2023).

Academic well-being is a multidimensional concept that comprises both affective and emotional dimensions, along with cognitive perspectives (Salmela-Aro et al., 2009b; Salmela-Aro & Upadyaya, 2014). In this dissertation, academic

well-being was conceptualized through schoolwork engagement and school burnout, along with momentary feelings of tiredness, stress, and anxiety during school days. Schoolwork engagement, which is an indicator of positive school-related well-being, consists of three components that are emotional, cognitive, and behavioral in nature and related to energy, dedication, and absorption in studying (Salmela-Aro & Upaduyaya, 2014). Energy refers to a positive approach to schoolwork, dedication to a positive attitude or motivation towards schoolwork, and absorption to an experience of concentration related to schoolwork.

The concept of school burnout has been adopted from the work contexts (Schaufeli et al., 2002). Similarly, with job burnout, school burnout can occur due to an imbalance between the psychological and practical demands and the personal resources an individual has for tackling these demands (Salmela-Aro & Upadyaya, 2014). School burnout can be seen as a negative indicator of academic well-being and consists of three dimensions: emotional exhaustion due to study demands, a cynical orientation towards school and studying, and feelings of inadequacy as a student (Salmela-Aro et al., 2009b). Emotional exhaustion refers to tiredness, sleep problems due to schoolwork, and ruminating over school-related issues. A cynical attitude towards schoolwork has been defined as a loss of interest in and and a loss of meaningfulness related to studying (Salmela-Aro et al., 2009b). Inadequacy as a student refers to feelings of lowered competence, achievement, and accomplishment as a student. In their meta-analysis, Chu et al. (2020) reported that social media use was not associated with emotional exhaustion in the work context, but adolescents may differ from adults because their self-regulative skills are not yet fully developed and the social norms among adolescents differ from those among adults.

The possible negative outcomes in academic well-being are seen as a result from an imbalance of the psychological demands and the resources available for tackling these demands (Demerouti et al., 2001). It has been conceptualized through a theoretical model called the demands-resources model (DR model). Because this dissertation focuses on academic well-being, the DR model was adopted as one of the main theoretical approaches. In the DR model, outcomes can be conceptualized over two processes: the energy-depleting process and the motivational process (Salmela-Aro & Upadyaya, 2014). The energy-depleting process refers to an effort-driven energetic process of overtaxing and wearing out, in which heavy demands exhaust energy and lead to burnout (Demerouti et al., 2001). The motivational process refers to a process in which a lack of sufficient resources precludes dealing effectively with heavy demands, leading to disengagement and fostering mental withdrawal (Demerouti et al., 2001).

On average, screen time as such is not a strong contributor to academic performance (Adelantado-Renau et al., 2019), but the associations are not linear (Przybylski & Mishkin, 2016; Przybylski & Weinstein, 2017), meaning that more time spent online is not linearly associated with lower academic well-being or

performance. No time spent online at all, or excessive time spent online can be more harmful for adolescent academic well-being than normative use. In the research literature this is referred to as the Goldilock hypothesis (see for example Hisler et al., 2020; Przybylski & Weinstein, 2017). Adolescents that are outside the online world may be excluded from other social experiences with peers while excessive online time may displace time from some important activities, such as sleep, studying, or face-to-face time spent with friends and family.

Empirically, social media use has been associated with higher school-related burnout among adolescents (Evers et al., 2020; Hietajärvi et al., 2019), and similar findings have been reported related to excessive Internet use (Salmela-Aro et al., 2017). In general, phone use was associated with higher emotional exhaustion and anxiety (Büchi et al., 2019), and high levels of television viewing and prolonged digital gaming and computer use associated with higher school-related stress (Khan et al., 2022). However, Walburg et al. (2016) reported that emotional exhaustion predicted more problematic Facebook use than vice versa, and this was common especially among girls. Given the ubiquitous presence of mobile technologies, adolescents can potentially receive social media notifications multiple times a day, thus increasing social demands and decreasing mental recovery time. Social media may generate feelings of constant availability (Nesi et al., 2018) and lead to higher levels of feeling exhausted. In line, Finnish adolescents who reported excessive and problematic forms of social media use were more likely to report feeling low and tired on school mornings (Lahti et al., 2021). The mechanisms underlying these associations can also be linked to the displacement of time from activities that promote academic well-being (such as sleep or physical activity) or the associations related to academic well-being can be motivational.

Related to disengagement at school, the links between socio-digital engagement and academic well-being can be motivational, meaning that if schools do not embrace adolescent interest in digital engagement, students may experience a sense of disengagement (Hietajärvi, 2019). Friendship-driven socio-digital engagement was associated with lower schoolwork engagement, and interest-driven socio-digital engagement associated with higher schoolwork engagement (Hietajärvi et al., 2020). Students who were interested in digital gaming and engaged with it heavily showed higher levels of disengagement in schoolwork than non-players did (Przybylski & Mishkin, 2016). Similarly, some qualitative case studies have proposed that student's interest-driven socio-digital engagement outside the school can both facilitate and obstruct engagement towards schoolwork (Deng et al., 2016; Gurung & Rutledge, 2014; Kruskopf et al., 2021). The associations likely depend on students' individual differences, such as identity, personality, or pre-existing dispositions toward schoolwork, which influence both how individuals engage in the digital world and the related academic outcomes (Mannerström et al., 2018).

To sum up, the literature shows that the links between socio-digital engagement and various domains of academic well-being are similarly complex. All the above-mentioned results indicate that academic well-being can be both an antecedent and an outcome, and students have differential susceptibilities to socio-digital engagement effects. In addition, long-term effects likely differ from short-term effects, and the effects that occur between individuals may differ from processes occurring within one individual. Multiple simultaneous mechanisms may explain the effects that socio-digital engagement has on adolescents' academic well-being. Researchers have explored sleep as a potential factor that could explain the associations between socio-digital engagement and well-being.

1.2.2 Socio-digital engagement and adolescent sleeping problems

As early as a decade ago, Gradisar et al. (2013) reported that most people, already from the age of 13, used some form of digital media within the hour before going to bed. The recommended sleep duration for optimal daytime functioning ranges between 8 and 10 h a night (Hirshkowitz et al., 2015); however, according to meta-analyses, adolescents aged 12 to 18 years get, average less than 7 h of sleep per night before a school day (Galland et al., 2018). In line, statistics from the School Health Promotion Study (2019), conducted by the Finnish Institute for Health and Welfare, show that approximately one-third of Finnish adolescents aged 15 to 17 report sleeping less than 8 h per night. However, adolescents are biologically programmed to stay up later, thus they are at risk for sleep loss (Exelmans & Van den Bulck, 2019). In 2019, 16% of girls and 8.1% of boys aged between 15 and 17 years reported having problems falling asleep at least once a week in Finland (School Health Promotion Study, 2019). Among upper secondary school students (aged 16–18), the equivalent percentages for girls in academic and vocational track were 14.5% and in 21.8%, respectively. For boys, the percentages were 7.1% in academic track and 9.2% in vocational track (School Health Promotion Study, 2019).

An average correlation has been observed among adolescents, aged 13–15 years, between spending time on social media in the evenings and having trouble falling asleep (Lund et al., 2021). Increased technology use is, on average, associated with later bedtimes (Bartel et al., 2015), and social media use is associated with poor sleep quality (Lund et al., 2021). Similarly, Brautsch et al. (2023) reported that the time spent on digital media was associated with shorter sleep duration and poorer sleep quality in late adolescence and early adulthood (16–25-year-olds). However, on average, the associations between technology use and sleep are negligibly small, explaining only a small part of the variation (Bartel & Gradisar, 2017).

Among some individuals, insufficient or poor sleep is a factor influencing the associations between social media use and well-being (Exelmans & van den Bulck, 2019; Meier et al., 2020), but problems with sleep are complex and multifactorial (biological and psychological), and therefore sleep researchers also have called for more multidisciplinary research to reveal these complex associations (Exelmans & Van den Bulck, 2019). The role of socio-digital engagement as a negative contributor to adolescent sleep has been under interest because problems with sleep can have negative health and well-being effects (Tarokh et al., 2016) along with negative effects in daily emotional functioning (Shochat et al., 2014). Moreover, these may further associate with academic well-being. The link between digital media exposure and impaired daytime functioning has been proposed to be mediated by sleep problems (Bartel & Gradisar, 2017; Cain & Gradisar, 2010). However, empirical research has reported contradictory results.

Previous literature has hypothesized three mechanisms that potentially lead to socio-digital engagement interfering with sleep and sleeping habits. First, digital activities may replace sleep by delaying bedtime. Second, physiological, cognitive, and emotional arousal may interfere with sleep (e.g., interactive digital gaming, computer-mediated studying, or chatting eagerly with friends). Third, exposure to bright light may disrupt the process of falling asleep (see Carter et al., 2016; LeBourgeois et al., 2017). This dissertation focuses on the sleep displacement mechanism, i.e., how socio-digital engagement is associated with delayed bedtimes and sleep quality.

Socio-digital engagement, which is an unstructured activity that has no specific starting or ending point, is more likely to displace time from other unstructured activities during leisure time (Exelmans & van den Bulck, 2018). Therefore, spending time online on social media may delay bedtime. However, it is worth noting that this displacement hypothesis may be especially true for young people. For adults, research has shown that socio-digital engagement is associated with delayed bedtimes but also with later rise times, indicating a shift in timing but not necessarily resulting in insufficient sleep duration (Exelmans & van den Bulck, 2019). Adolescents that need to wake up for school have limited autonomy towards their waking-up times, thus delayed bedtime may result in reduced sleep time, which may further impact daytime functioning at school or increase the risk for school burnout in the long run, for example.

Indeed, poor sleep quality has been linked to overall school-related burnout or exhaustion (Liu et al., 2021; May et al., 2020), and social media use was associated with lower academic well-being through reduced sleep (Orzech et al., 2016; Scott & Woods, 2019). Disturbed sleep due to social media use mediated the relationship between school burnout and lower academic achievement (Evers et al., 2020; Scott & Woods, 2019). A study conducted on Chinese adolescents showed that sleep quality mediated the relationship between problematic smartphone use and lower schoolwork engagement and higher disengagement (Li et al., 2023). A

Finnish study suggested that students with more maladaptive motivational profiles toward schoolwork are at a greater risk of sleep impairment due to social media use (Mädamürk et al., 2021). Digital engagement that leads to reduced sleep duration (Hale & Guan, 2015; Hökby et al., 2016) may result in higher emotional dysregulation (Gilchrist et al., 2023) and to a perception that schoolwork is more demanding, along with contributing to depleted cognitive and social resources and increased fatigue during school days. Evers and others (2020) reported that disturbed sleep due to social media use mediated the relationship between school burnout and lower academic achievement (Evers et al., 2020). Using digital media in the evening can be harmful for sleep and may increase daytime sleepiness at school, especially for adolescents with evening chronotype (Kortesoja et al., 2023) or for those who perceive social media use and the constant pressure to remain available as stressful (van der Schuur et al., 2019).

It is important to note that adolescence is a period of life that is characterized by staying up later in the evenings (Crowley et al., 2018), and sleep onset problems (Exelmans & Van den Bulck, 2019) and insufficient and poor sleep are common (Galland et al., 2018; Matricciani et al., 2012). Behaviors that are common in young people (e.g., using a mobile phone while in bed) are expected to increase shuteye latency, i.e., the time spent in bed before falling asleep (Fossum et al., 2014), thus further delaying bedtime. Adolescents report that shutting down social media to avoid sleeping difficulties means an increased fear of not belonging to the peer group the next day (Jakobsson et al., 2022). That said, socio-digital engagement is not only concerned with time spent online but is tied up with the key developmental tasks of adolescence, the social norms of availability, and keeping up with friends.

It is likely that how an individual uses social media moderates the effects of socio-digital engagement on sleep outcomes (Scott & Woods, 2019). For example, excessive social media use has been associated with difficulties in falling asleep among adolescents aged 13–15 years (Scott et al., 2019) and with poor sleep quality among youths aged 16–25 years (Alonzo et al., 2021). A recent meta-analysis, focusing on longitudinal studies, reported that social media use, as one form of socio-digital engagement, had a negative but rather small effect on sleep health among adolescents (Pagano et al al., 2023). A recent cross-national study from 18 European and North American countries suggested that problematic social media use is more harmful for sleep and pushes back bedtime more than normative social media use (Boniel-Nissim et al., 2023). Hisler et al. (2020) discovered similar results among adolescents aged 13 to 15 years in the United Kingdom, highlighting that excessive social media use displayed stronger associations with longer sleep latency and sleep duration compared to normative use.

As said, earlier studies that have focused on between-person differences have suggested that, on average, using a smartphone in the evening associates with later bedtimes, poor sleep quality, and daytime sleepiness among adolescents (Hale et

al., 2019; Kubiszewski et al., 2014; Lemola et al., 2015). However, research with more intensive study designs and focusing on short-term effects (i.e., the experience sampling method) has recently reported contrary results among both adolescents and young adults. For example, Harbard et al. (2016) showed that pre-sleep cognitive arousal mediated the associations between social media use and sleep onset latency (the time it takes to fall asleep) among adolescents (mean age 16.2 years), but this was only true on vacation nights and social media use did not associate with later bedtimes or other sleeping problems on nights before school (Harbard et al. 2016). Also, using the experience sampling method, Siebers et al., (2023, preprint) did not find remarkable associations between pre-bedtime smartphone use and poor sleep quality among Belgian adolescents (mean age 14.5 years, SD = 0.7, range = 13–16 years). Similarly, Tkaczyk et al. (2023) reported that pre-bedtime smartphone use was not associated with later bedtimes in Czech adolescents (mean age 15.0 years, SD 1.46, range 12–17). In line, Das-Friebel and others (2020) showed that social media use was not detrimental to objectively measured sleep among young adults.

To conclude, some form of socio-digital engagement in certain situations may be harmful for the sleep of some adolescents (Exelmans & van den Bulck, 2019; Meier et al., 2020), but these associations are complex, and more nuances for empirical research are needed (Exelmans & Van den Bulck, 2019). Next, I sum up the theoretical perspectives adopted in this dissertation and describe the main aims and research questions posed by this thesis.

1.2.3 The theoretical perspectives adopted

This dissertation approaches media effects from the perspective of technology effects, where socio-digital engagement is seen as a possible causal factor contributing to declines or improvements in the sleep or academic well-being of adolescents (see Meier & Reinecke, 2021). In addition, this dissertation focuses on normative use, neglecting addictive and problematic forms of behavior (such as digital gaming addiction or problematic social media use) related to adolescent socio-digital engagement. Combining perspectives from multiple research fields was possible due to the dissertation's multidisciplinary focus comprising media and communication, educational and developmental psychology, and sleep research. The interplay between socio-digital engagement on adolescent sleep and academic well-being was approached from the viewpoints of 1) differential susceptibilities to media effects (Valkenburg & Peter, 2013), 2) the demands-resources model of academic well-being (Salmela-Aro & Upadaya, 2014), and 3) sleep displacement hypothesis (Bartel & Gradisar, 2017; Exelmans & Van Den Bulck, 2018). These perspectives were used as conceptual tools to explain the possible varying relations and mechanisms connecting socio-digital engagement, sleep, and academic

well-being in the context of adolescence. Figure 1 sums up and represents how these three theoretical perspectives were intertwined.

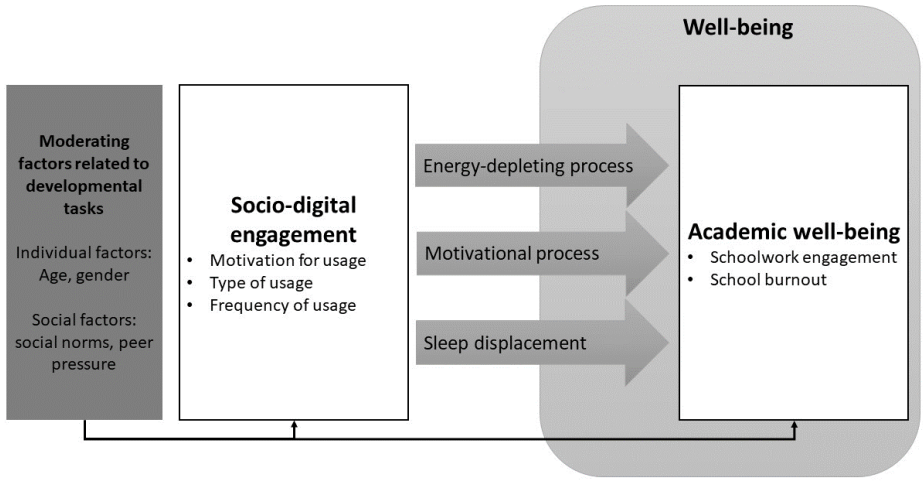

Figure 1. Synthesis of the adopted theoretical perspectives.

2 AIMS

The overall aim of this dissertation was to investigate the complex interplay between adolescent's socio-digital engagement and academic well-being while considering the role of sleep, a research area that has received less attention. The first aim was to examine how various types of socio-digital engagement are associated with sleep domains and academic well-being at different phases of adolescence considering both short- and long-term effects. The second aim was to investigate the potential moderating factors that explain individual differences in the associations between socio-digital engagement, sleep, and academic well-being. The third aim was to address various theoretical mechanisms and processes between different forms of socio-digital engagement and academic well-being. Previous studies have already identified some links between socio-digital engagement and academic well-being, merely focusing on motivational processes. This dissertation, however, focused also on processes that occur through the energy-depleting process and sleep displacement.

Three main research questions addressed in this thesis:

1. How are various forms of socio-digital engagement associated with sleep and academic well-being at different developmental phases during adolescence? (Study I, Study II, Study III)
2. How do social pressure and the related availability stress moderate the daily links between social media use, sleep, and academic well-being? (Study III)
3. In light of developmental and contextual factors, how can we conceptualize the processes linking socio-digital engagement and academic well-being? (Study IV)

This dissertation consisted of four original studies. Studies I, II, and III were empirical studies using a quantitative approach, and Study IV was a narrative review using a qualitative approach. Study I examined the associations between various forms of socio-digital engagement (including digital gaming), sleep quality, and academic well-being in early adolescence (ages 12–13 years). It addressed the direct and indirect effects of socio-digital engagement on academic well-being through sleep quality. Differences between genders were examined. Study I was a cross-sectional survey study collected in 2013. The first research question was addressed in Study I.

Study II extended the results obtained in Study I by investigating the longitudinal associations between active social media use, bedtimes, and school-related emotional exhaustion across the years of adolescence (from ages 13–14 until ages 18–19). Study II was a longitudinal survey study with yearly follow-ups between

2014 and 2019. Associations were examined both on the within-person and the between-person levels. Within-level associations in Study II reflected time-varying temporary increases or decreases in relation to an individual's typical level. Moreover, between-level associations reflected a time-invariant typical level of each individual across time. In addition, autoregressive paths were examined that considered the possible carryover effect in social media use, bedtimes, and emotional exhaustion for each individual from one datapoint to another. The first research question was also addressed in Study II.

Study III was an experience sampling study, where the associations between social media use close to bedtime, objective bedtimes, perceived sleep quality, and academic well-being were investigated on a daily level in late adolescence (ages 17–18). Study III was conducted during eight school days in 2018, during which adolescents reported their academic well-being through feelings of tiredness, stress, and anxiety during school days. In addition, objective bedtimes were collected using activity bracelets. Study III also investigated how social pressure and availability stress moderated the daily associations between social media use, sleep, and academic well-being. Both the first and second research questions were addressed in Study III.

Study IV was a narrative review that addressed theoretical processes between socio-digital engagement and academic functioning, defined as academic well-being, performance, and engagement. The third research question was addressed in Study IV by examining existing meta-analyses, reviews, and key studies on the topic. As a result, a Developmental-Contextual Digital Demands and Resources model (DC-DDR) was introduced.

3 Methods

3.1 Study context

One of the basic principles of Finnish education is that it is of high quality, equal, and accessible to all people (see Finnish education in a nutshell, 2022; Lonka, 2018). In principle, everyone has the same educational opportunities irrespective of background, such as ethnic origin, age, wealth, or residence. Study materials are free during comprehensive education, and everyone is given a free warm meal daily. Education itself is free at all levels. Most institutions are public, but some private institutions exist. However, most private institutions do not differ from publicly maintained ones. They also receive public funding and follow the same national core curricula and qualification requirements as those followed by public institutions. There is hardly any private tutoring. Teachers in Finland are highly educated and have pedagogical autonomy, which means they can decide for themselves which teaching methods and learning materials they use. There are no school inspections.

Children in Finland begin school the year they turn seven, and compulsory education lasts for 12 years. Primary education (grades 1–6, age range from 6–7 to 12–13 years) and lower secondary education (grades 7–9, age range from 13–14 to 15–16 years) is provided in comprehensive schools. Education is compulsatory until the age of 18, but this regulation only became valid in 2022. Thus, it was not valid during the data collection of this thesis. The Finnish education system has no dead-ends, meaning that students can always continue their studies at any level of education if they meet the admission requirements of the level in question. After lower secondary school, education continues either in upper secondary school (the so-called academic track) or in vocational school. Which track a student follows is mainly selected by the individual themselves based on their own interest, but grades recorded in lower secondary school play a crucial role. Upper secondary school lasts, on average, three years (grades 10–12, age range from 16–17 to 18–19 years). Entering upper secondary school in the capital region of Finland (where participants in this study were selected from) is highly competitive, especially in the academic track. The transition from lower secondary school to upper secondary school is a key educational transition among Finnish adolescents. Completing upper secondary education, along either the academic or vocational track, provides students the eligibility to continue onwards to higher education.

The Finnish National Agency for Education determines the national core curricula for various educational levels. The national core curricula contain objectives and core contents of subjects and transversal competencies that cross subject

boundaries. The curricula are developed through broad-based consultations involving educational officials, researchers, and stakeholders of relevant sectors and disciplinary fields. In the vocational track, students acquire competencies, which are assessed based on criteria defined in the national qualification requirements. The national education curricula in Finland emphasize broad competencies in "21st century skills" that are related to, for example, improving the well-being of self and others, socio-emotional skills, digital skills, and life management skills. Hence, it is presumed that schools bear the responsibility for instructing these skills.

In PISA 2018 (the Programme for International Students Assessment in OECD countries), Finnish students scored higher than the OECD countries on average in reading, mathematics, and science. However, the results have been declining since 2006, which is a large public concern in Finland. An increase in school burnout prevalence is another concern in Finland, as it generally increases in upper secondary school, especially among students on the academic track (Salmela-Aro & Tynkkynen, 2012), and is more common among girls than boys (Read et al., 2022; Salmela-Aro & Tynkkynen, 2012). Burnt-out students are shown to experience more academic failure, school dropout, and other negative psychosocial outcomes (Salmela-Aro, Savolainen, & Holopainen, 2009a). However, the majority of students enjoy going to school, as shown by the Finnish School Health Promotion Study in 2019, which reported that 60% of adolescents in lower secondary school and 70.9% (academic track) and 81.5% (vocational track) of adolescents in upper secondary school reported enoying going to school a lot or quite a lot.

3.2 Procedure and participants

All the empirical datasets used in this dissertation were drawn from the Mind the Gap (PI Kirsti Lonka; #265528) and Bridging the Gaps (PI Salmela-Aro; #308351, co-PI Kirsti Lonka; #308352) projects, which were funded by the Academy of Finland. Project Mind the Gap began in 2013 by collecting a large cohort study from the capital area of Finland. It continued by conducting yearly follow-up surveys between 2014 and 2016. Then, project Bridging the Gap continued in 2017 by a follow-up of the same participants with yearly surveys and additionally by collecting an intensive longitudinal dataset that included experience sampling data and ambulatory assessments of sleep and other physiological states (more detailed description under Data collection in Study III). Project Bridging the Gap was active until 2022. Table 1 summarizes the main aims, participants, measures, approaches, and data analyses conducted in the original studies I, II, and III.

Table 1. Overview of the main aims, participants, measures, approaches, and data analyses utilized in original studies I–III.

	Study I	**Study II**	**Study III**
Main aims	To examine inter-individual associations between socio-digital engagement, sleep quality, and academic well-being in early adolescence.	To examine intra-individual associations between active SMU, school-related emotional exhaustion, and bedtimes across the years of adolescence.	To investigate adolescent pre-bedtime SMU, same-night sleep, and academic well-being the next day. In addition, to explore moderators that may explain variation in the effects between individuals.
Participants: N	749	426	143
Participants: Age (in years)	12–13	13–19	17–18
Participants: Gender distribution	55% female	65.7% female	68% female
Educational context	Comprehensive school 6th grade	From lower secondary school to upper secondary school	Upper secondary school 2nd grade
Year of data collection	2013	2014–2019	2018
Type of data collection	A single self-reported questionnaire	Five yearly follow-up self-reported questionnaires	Two-week experience sampling combined with physical ambulatory measurements
Measures	SDPi, self-reported sleep quality index, School Burnout Inventory, Schoolwork Engagement Inventory	SDPi, self-reported bedtime, School Burnout Inventory	Evening active and passive SMU, objective bedtime, self-reported sleep quality, self-reported bedtime, momentary academic well-being
Approach	Cross-sectional, between-person	Longitudinal, within- and between-person	Intensive, longitudinal, within- and between-person
Data analyses	Confirmatory factor analysis, Structural Equation model (mediation model)	Random intercept cross-lagged panel model	Multilevel structural equation model with cross-level interaction

Note. SMU=social media use

3.2.1 Data collection in Studies I and II

The data in Studies I and II consisted of self-reported questionnaires. Questionnaire responses were collected in two ways: through schools or by contacting each participant personally. The sample was a convenience sample, which means that all participants and schools that were willing to participate were included in the dataset. Participation in all data collections was voluntary, and informed consent forms were collected from the students and from the parents of under 18-year-old students. Schoolteachers and other personnel that were able to organize the data collection administered the questionnaires during school hours with the help of personnel from the research projects. Students who were not present at school on the day of data collection were sent a link to the questionnaire via a personal text messages or email.

3.2.2 Data collection in Study III

Study III was an experience sampling study (ESM) that included data from a baseline questionnaire, daily questionnaires related to sleep and evening activities, and momentary reports of tiredness, stress, and anxiety during the school days. ESM can reduce the methodological disadvantages of other retroperspective or general-level self-reports by capturing experiences closer to the context and time in which they occur. ESM allows collecting data from which intra-participant behavior patterns can be identified rather than focusing on inter-participant behavior patterns (Conner et al., 2009). ESM allows focusing on activities, thoughts, and feelings in a specific context (i.e., during school days) (Hektner et al., 2007). In Study III, interval-contingent sampling was used, meaning participants were signaled via smartphones at random times over the course of several days to respond to a short self-report questionnaire (Hektner et al., 2007). Between days 2–12, each participant answered the short ESM questionnaires relating to feelings of tiredness, stress, and anxiety on four separate occasions (at random times between 8 am and 4 pm) during eight school days. In addition, participants were signaled at a fixed time each morning with questionnaires related to the previous evening and night. Engagement in social media in the evening and sleep-related questions were enquired from participants in a delayed manner the next morning, so as not to disturb the participants late in the evening.

During the ESM data collection period, physical measures of sleep and other physiological states were collected using ambulatory assessments. On the first day of the ESM, a baseline questionnaire was completed, measuring perceived social pressure and availability stress related to constant online accessibility. This was filled out at an orientation meeting where the researchers and research assistants met with the participants and distributed the data collection devices, i.e., POLAR M460 activity bracelets and mobile phones, to each participant for the daily ESM

questionnaires. All practical information was explained during this meeting (i.e., how to use the activity bracelets or how to fill out the ESM questionnaires).

Participants answered the ESM questionnaires using smartphones distributed by the research project, and the questionnaires were sent using the PACO software (https://pacoapp.com/), which is a free ESM software available in application stores for Android-based smartphones. Objective bedtimes were detected from the activity bracelets that participants were asked to wear continually during the study period. Objective measurements were collected using Polar M460 activity bracelets. They detected physical activity using an accelerometer and measured the metabolic equivalent of the task (MET) value every 30 seconds. It expresses the intensity and energy expenditure of physical activities, making it possible to track sleeping and resting times. Data were exported from the activity bracelets using the Polar Go Fit web service (https://www.polargofit.com/help/teacher/en/Content/References/Polargofit.com%20user%20guide%20for%20teacher.pdf). Data collection lasted 12 consecutive days, but due to the academic well-being aim of Study III, weekends and other holidays were excluded from the analyses. To ensure good engagement in the study, all participants were added to a WhatsApp group at the beginning of data collection (a separate WhatsApp discussion for each group from different schools), and this platform acted as a channel for interacting with all the research project personnel if any technical problems emerged with the devices or questions came up related to the study. Researchers occasionally sent out reminder messages to keep participants engaged for the duration of the study period. Due to the intensive nature of ESM data collection, participants afterwards received a 20-euro gift card and a summary report of their own physical activity and sleep, which was based on the data gathered during the study period.

The response rate in the ESM study was good. Overall, the assessment procedure resulted in a maximum of 60–66 completed momentary questionnaires for each participant, i.e., 9270 questionnaires overall. A total of 6558 questionnaires were completed (70.7%). Of those, the average number of completed questionnaires per person was 43.7 (ranging from 16 to 61). Analyses in Study III included N=1102 data points, selected based on the research aim.

3.2.3 Literature review in Study IV

Study IV was a qualitative narrative review that constituted the key studies, systematic reviews, and meta-analyses related to the interplay between socio-digital engagement, academic well-being, and school performance. As typical for literature reviews, a new conceptual model was introduced that summarized the literature reviewed in Study IV. Previous reviews have focused on the interplay between socio-digital engagement and school performance (i.e., Adelantado-Renau

et al., 2019) or well-being and school performance (i.e., Kaya et al., 2021). Therefore, Study IV aimed to contribute to the literature by introducing new insights to the interplay considering socio-digital engagement, academic well-being and school performance.

3.2.4 Participants

Participant descriptives in each empirical study are presented in Table 1. Data for Study I were collected in 2013 in the capital region of Finland. Participants were sixth graders (aged 12–13 years, N=749), which is the last grade of primary school in Finland. The participants filled out a self-reported questionnaire during school hours. School personnel organized the data collection in schools with the help of the research project personnel. Altogether, 36 schools participated in the data collection.

The dataset used in Study II was follow-up data collected in the same capital region. However, participants in Study I transferred to secondary school in 2014 and some participants from Study I were therefore not reached anymore and new participants were included in the follow-up, thus the participants in Study II were only partly the same as in Study I. A yearly follow-up was organized between 2014 and 2019. Each year, the former participants were contacted and new participants were additionally included in the dataset. In Study II, N=426 participants were included in the analyses. These students participated in at least four out of the five follow-up waves during 2014 and 2019.

Study III utilized data from three sources: the baseline questionnaire, a two-week experience sampling questionnaire data, and physical ambulatory measures of objective bedtimes. Participants in Study III were second-year high school students (17–18-year-olds), and the data were collected in spring 2018 during April and May. The sample in Study III was a subsample of the cohort that was followed in the Mind the Gap and Bridging the Gap projects. Interest to take part in this two-week intensive study was enquired when students participated in the cohort follow-up survey earlier in 2018 (time point 4 in Study II). A list of interested participants was compiled, and seven groups from six schools were chosen to take part in this study. Due to the practical resources, schools with the highest number of students showing interest in this ESM study (considering the location of the school) were included. All participants were contacted personally by calling them and explaining the study protocol (i.e., wearing an activity bracelet day and night, answering ESM questionnaires multiple times per day). After the phone call, participants decided whether they wanted to join the study. The data were collected over consecutive weeks for each group because we had a limited amount of activity bracelets and mobile phones to use in the data collection. Altogether N=313 students reported interest in the study from the six chosen schools, and in the end,

N=155 took part in the study. Some participants were excluded from the analyses due to limited responses (data from less than four school days). The final sample size was N=140 on the student level, including N=1102 data points at the within-student level.

3.2.5 Measures

To answer the research questions of this dissertation, multiple and diverse measures were utilized in Studies I, II, and III (see Table 1 for a summary). Most of the scales used in this dissertation were selected based on previous literature and empirical research and were validated in Finnish samples beforehand.

Measures of socio-digital engagement

Socio-digital Participation Inventory

Forms of socio-digital engagement were measured using the dimensions of the Socio-Digital Participation Inventory (SDPi; Hietajärvi et al., 2016; 2019) that was used in applicable parts in Studies I and II. SDPi measures the frequency of various socio-digital engagement forms, including digital gaming (Hietajärvi, 2019). The validity of the inventory has been established by several Finnish studies focusing on various age groups (Hietajärvi et al., 2015; Hietajärvi et al., 2019; Li, 2019). SDPi consists of a wide array of complex digital activities. Only specific parts were included in this dissertation that were related to the research questions set to the original studies. Socio-digital engagement was enquired with the question "How often do you partake in the following activities online" and digital gaming was enquired with "How often do you play games on a phone, game console, or computer?". The items were measured on a scale: 1 = never, 2 = a couple of times a year, 3 = monthly, 4 = weekly, 5 = daily, 6 = multiple times a day, 7 = all the time.

In Study I, 19 items related to socio-digital engagement and digital gaming from the original inventory were included. Friendship-driven socio-digital engagement was measured with three items (e.g., "I follow the profiles, pictures, and activities of my friends"). Entertainment-driven socio-digital engagement was measured with two items (e.g., "I watch videos and photos online (i.e., YouTube, Vimeo, Flick, Tumblr)"). Knowledge-driven socio-digital engagement was measured with four items (e.g., "I search for new information about my hobbies or things I am interested in"). Digital gaming was measured with 10 items. Recreational gaming (fun, movement, music/rhythm/dance, or puzzle games) was measured with four items, sports gaming (sports and motor sports games) with two items, and action gaming (role, strategy, shooting, and adventure games) with four items.

In Study II, active social media use was measured with items from SDPi that were particularly related to friendship-driven socio-digital engagement. These were conceptualized as mixed active social media use because the items reflected both private and public social media use. These four items were "I chat", "I visit and send messages via social media sites", "I post updates or share interesting content", "I post pictures or picture updates".

Pre-bedtime active and passive social media use

In Study III, evening active and passive social media use were measured with open reports that I manually categorized. Each morning participants answered the question "What did you do 30 minutes before going to bed?". I found nine categories: chatting, scrolling, watching videos, viewing TV/series, studying, listening to music, gaming, reading, and other. These are presented in Table 2 along with descriptive statistics. All answers were coded as dummy variables. If there were cases that included activities from several categories (for example, "I scrolled social media and watched YouTube videos"), they were coded as 1 in all the related categories. Due to the focus of Study III, only answers related to active (chatting) and passive (scrolling) social media use were included in the multilevel analyses. The active and passive categories were both activities related to social media use, but their difference lies in the direction of interaction (Meier & Reinecke, 2021). Active was defined as two-way interactive use, and passive was defined as one-way non-interactive use. Out of all responses, 27% included active social media use and 29% included passive social media use.

Table 2. Categories for the open reports of evening activities in Study III

Category	Example responses	N	M	SD
Chatting (active social media use)	"I messaged with my friends" "I sent good-night wishes to my friends" "I chatted with friends"	247	.27	.44
Scrolling (passive social media use)	"I browsed social media" "I was on Instagram" "I scrolled through social media" "I hung out online"	261	.29	.45
Watching videos	"YouTube" "I watched videos"	69	.08	.26
Watching TV/series	"I watched Netflix" "I watched TV"	186	.20	.40
Studying	"I studied" "I wrote an essay" "I studied for an exam"	67	.07	.26
Listening to music	"I listened to music"	68	.07	.26
Gaming	"I played a game" "Xbox"	16	.02	.13
Reading	"I read a book" "I read"	53	.06	.23
Other	"I took a shower" "I ate" "I took my dog for a walk" "I set out my things, ready for the next day"	137	.15	.36
Note. A total of N=1020 reports for evening activities were categorized.				

Measures of academic wellbeing

School Burnout Inventory

School burnout was measured using the School Burnout Inventory (SBI; Salmela-Aro et al., 2009b) and was used in Studies I and II. The Inventory consists of three subscales: emotional exhaustion at school, cynicism towards the meaningfulness of school, and a sense of inadequacy as a student. Emotional exhaustion was measured with three items (e.g., "I feel overwhelmed by my schoolwork"),

cynicism with three items (e.g., "I feel that I am losing interest in my schoolwork"), and inadequacy with two items (e.g, "I often have feelings of inadequacy related to my schoolwork"). All items were rated on a scale ranging from 1 (=completely disagree) to 6 (=completely agree). All three dimensions were included in Study I, but Study II focused only on the emotional exhaustion dimension.

Schoolwork Engagement Inventory

Schoolwork engagement was assessed with a Schoolwork Engagement Inventory (EDA; Salmela-Aro & Upadyaya, 2012), which measures trait-like and long-term, study-related positive states of mind. It consists of three subscales, i.e., energy, dedication, and absorption, all of which are measured with three items (energy: e.g., "When I study, I feel I am bursting with energy"; dedication: e.g., "I am enthusiastic about my studies"; absorption: e.g., "Time flies when I am studying"). The Schoolwork Engagement Inventory is often utilized as a unidimensional measurement that represents a generally positive study-related state of mind (Salmela-Aro & Upadyaya, 2012). All items were rated on a scale ranging from 1 (=never) to 7 (=every day). Schoolwork Engagement Inventory was used in Study I as a unidimensional construct.

Momentary academic well-being

In Study III, momentary feelings of tiredness, stress, and anxiety were measured with single-item self-reports four times (between 8 am and 4 pm) per school day during the ESM study. Participants answered the question "How well do the following words describe your feelings? At the moment I am...tired/stressed/anxious." Responses were given on a 7-point scale ranging from 1 – Not at all to 7 – Very much. In Study III, tiredness, stress, and anxiety were aggregated measures from four momentary reports measured across school days between 8 am and 4 pm.

Measures of sleep

Self-reported bedtime

Studies I and II enquired about self-reported bedtime using one item "What time do you usually go to bed when you have school the next morning?". In Study III, self-reported bedtime was asked about each morning using one item "What time did you went to bed? (The time you turned off the lights and laid your head on the pillow, e.g., 22:00)". Participants responded in open-text boxes and thus, the clock times were transformed into numeric expressions with continuous regular intervals (e.g., clock time 22:30 was transformed into value 22.50). If the participants provided several times or a timeframe (e.g., 21:00–22:00), a mean was calculated.

A clock time past midnight (24:00) was coded higher in the regular interval continuum (e.g., 01:00 was coded as 25.00).

Objective bedtime

In Study III, objective bedtimes were measured using MET values (expressing the intensity and energy expenditure of physical activities) that were exported from activity bracelets (Polar M460) that were continually worn by the students (24 h/day and night). The bracelet measured a MET value every 30 seconds and, after data collection, the data were exported from the device using the Polar Go Fit web service (https://www.polargofit.com/help/teacher/en/Content/References/Polargofit.com%20user%20guide%20for%20teacher.pdf). Bedtimes were detected heuristically by a self-developed algorithm (developed by a technical data consultant from the research group) from Polar raw MET values considering the daily self-reported sleeping times.

Perceived sleep quality

Perceived sleep quality was measured in two ways. In Study I, participants reflected on their perceived sleep quality during the past six months "How well have you slept during the past six months" on a four-point scale (1= very badly, 2=quite badly, 3=quite well, and 4=very well). In Study III, perceived sleep quality was measured with one self-report question each morning: "How well did you sleep last night?". Response options were 1) well, 2) fairly well, 3) moderately, 4) fairly badly, and 5) badly. In the analyses, response options were reversed so that finally a value of 1 indicated "badly" and a value of 5 indicated "well".

Sleep quality index

In Study I, a sleep quality index was calculated for each participant. It was a combination of perceived sleep quality, sleep duration, and bedtimes (see Table 3). The items were drawn from the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman & Kupfer, 1988). Participants were asked to estimate their sleep duration in general by asking them "How many hours per night do you usually sleep?". Bedtimes on school days were asked by "What time do you usually go to bed when you have school the next morning?". Both sleep duration and bedtimes were open reports that were later transformed into numeric values as descripted above (see coding from Self-reported bedtime). Subjective sleep quality was measured by asking "How well have you slept during the past six months?". The question was rated on a scale of 1= very badly, 2= quite badly, 3= quite well, and 4= very well. Each participant obtained a value for subjective sleep quality, sleep duration, and bedtime that varied between 0 and 3, with a higher value reflecting better sleep quality. The index value for each participant was then a sum of each component and varied between 0 and 9.

Table 3. Sleep quality index used in Study I.

Subjective sleep quality: How well have you slept during the past six months?
Very well = 3
Quite well = 2
Quite badly = 1
Very badly = 0
Bedtime: What time do you usually go to bed when you have school the next morning?
Before 22.00 = 3
Between 22.00 and 23.00 = 2
Between 23.00-00.00 = 1
After 00.00 = 0
How many hours per night do you usually sleep?
> 9 hours = 3
8 to 9 hours = 2
7 to 8 hours = 1
< 7 hours = 0
Note. Sum of the three-component index varied between 0 and 9

3.2.6 Ethical considerations

All data collections related to the original studies received approval from the ethical review board of the University of Helsinki. Written consent was obtained from all participants in accordance with the Declaration of Helsinki and each participant had the opportunity to withdraw from the study at any time without consequences. Participation in all data collections was voluntary and participants were clearly informed about their rights during and after the data collections. In addition, parental consent was required for all under-18-year-old participants.

3.3 Data analyses

This dissertation adopted variable-oriented methods and the structural equation modelling framework (SEM). This approach helps to understand how variables are associated with each other and how predictor variables contribute to outcome variables (Laursen & Hoff, 2006). The SEM framework is a family of statistical models that consist of regression analysis, path analysis, and factor analysis. Multilevel SEM includes all of the above but is also expanded to deal with the opportunities of hierarchically clustered data. Repeated measures and clustered data in Studies II and III allowed using multilevel SEM by decomposing the variance of the variables into between and within levels. This enabled a better understanding of how the associations vary both within individuals and between individuals.

IBM Statistical Package for Social Sciences (SPSS) was utilized in Studies I, II, and III for data management and preliminary analysis. In Studies I–III, the primary analyses were conducted using Mplus (Study I version 7.4, Study II version 8.3, and Study III version 8.6; Muthén & Muthén, 1998-2017). Analyses in Studies II and III were conducted in conjunction with R and RStudio (R Core Team, 2018) with the package MplusAutomation (Hallquist & Wiley, 2018). See Table 1 for an overview of the statistical data analyses utilized in each original study.

In all empirical studies (Studies I, II, and III), missing data were estimated using the full-information maximum likelihood procedure and maximum likelihood with robust standard errors (MLR) as the estimator (Muthén & Muthén, 1998–2017). In addition, to detect multivariate outliers, individual cases were examined and excluded if they exhibited implausible response patterns, such as highly improbably or inconsistent answers (Bennett, 2001). Missingness was examined based on the overall percentage of missing data and the percentage of missing responses for each individual item. Little's MCAR test was utilized in Study II to determine the randomness of the missing values and their percentages.

Internal measurement consistencies

Internal consistencies of the measures in Studies I and II were examined using Cronbach's alphas. In Study I, they were computed using SPSS software, while bootstrapped confidence intervals and point estimate coefficients were used to compute internal consistencies in Study II using the R package MBESS (Kelley, 2016).

Estimation and model selection

Model fits (Hu & Bentler, 1998) in Studies I and II were evaluated based on $\chi 2$ and the root mean square error of approximation (RMSEA) with an approximate acceptable cut-off value less than 0.08, the standardized root mean residual (SRMR) with an approximate cut-off value less than 0.08, and the comparative fit index (CFI) and the Tucker-Lewis index (TLI) with acceptable cut-off values of

more than 0.90 (Hooper, Coughlan & Mullen, 2008). In Study III, model fits were evaluated based on Akaike and Bayesian information criteria (AIC, BIC, and aBIC) that are often used for model comparisons (Schwarz, 1978). Lower BIC and AIC values indicate better model fit.

Independent samples t-test

In Study I, mean differences were examined in the socio-digital engagement dimensions between genders. These were examined with an independent samples t-test that compares the means of two groups (Ross & Willson, 2017).

Confirmatory factor analysis

In Study I, the measurement models for girl and boy samples were specified using a confirmatory factor analysis (CFA) to examine the relationships between a set of observed variables and a set of continuous latent variables. CFA allows postulating a hidden unobserved variable (factor) that causes correlations between observed variables. The aim of CFA in Study I was to confirm similar factor structure as that reported earlier by Hietajärvi et al. (2016), focusing especially on items related to socio-digital engagement and digital gaming, and to confirm similar factor structures for girls and boys.

Structural equation model (SEM)

In Study I, SEM was utilized to explore the relationships between socio-digital engagement and academic well-being, which were assumed to be mediated by poor sleep. Study I was conducted as a cross-sectional study, which means that causal interpretations cannot be made. However, from a theoretical standpoint, we hypothesized that socio-digital engagement would be linked with poor sleep quality, and in turn, poor sleep quality would be associated with lower levels of academic well-being. The models in Study I consisted of two parts: a measurement and a structural part. Mean differences in the variables that were of interest (see Table 4 in section 4 Overview of the main findings from the original studies), supported the approach of conducting the models separately for both genders.

Random Intercept Cross-lagged Panel model

The aim of Study II was to address the within-person changes and between-person differences across adolescence related to active social media use, bedtimes, and emotional exhaustion. Therefore, a random intercept cross-lagged panel model (RI-CLPM) was utilized (Hamaker et al., 2015). With RI-CLPM, the dynamics and reciprocal relations between active social media use, emotional exhaustion, and self-reported bedtimes were examined (see Figure 2. Theoretical random intercept cross-lagged panel model from Study II). This type of longitudinal modeling, enabled examining the question of whether the present level of active social media use has consequences for future emotional exhaustion — and vice versa. In

addition, the model allowed investigating whether an increase in active social media use at a given timepoint is associated with increased emotional exhaustion or later bedtimes at the same timepoint. Bedtimes were included in the model to control for the effect of delayed bedtimes on emotional exhaustion and social media use (as suggested by the sleep displacement hypothesis).

The RI-CLPM consists of three components: grand means, stable between components, and fluctuating within components (Mulder & Hamaker, 2021). Grand means are means over all individuals at one timepoint (i.e., ASMU T1, EXH T1, or BT T1 in Figure 2). The between-level components are random intercepts (BETWEEN SMU, BETWEEN EXH, and BETWEEN BT in Figure 2) that capture individuals' time-invariant deviations from the grand means and thus represent the stable differences between individuals. These random intercepts were specified by creating a latent variable with the repeated measures of active social media use, emotional exhaustion, and bedtimes, and the indicators and factor loadings were fixed to 1. A statistically significant and positive covariance between the random intercepts would indicate that, for example, individuals who report more active social media use, in general, also report higher emotional exhaustion in general. The within components (i.e., WITHIN ASMU T2, WITHIN EXH T2, or WITHIN BT T2 in Figure 2) in the model represented the differences between an individual's observed measurements and their expected score based on the grand means and random intercepts. A statistically significant positive association between the within-level variables would indicate, for example, that if individuals report higher-than-usual social media use (compared to their personal typical level) they likely also report higher-than-usual emotional exhaustion.

The autoregressive effects (i.e., the path from WITHIN ASMU T1 to WITHIN ASMU T2) represent the within-person carry-over effects (Mulder & Hamaker, 2021). If the path coefficient is positive, it indicates, for example, that an individual who reports more frequent active social media use relative to their personal expected score, is likely to report higher active social media use relative to their personal expected score also at the next occasion.

On the other hand, the cross-lagged effects represent a spill-over of the state in one domain into the state of another domain (Mulder & Hamaker, 2021). A positive cross-lagged effect between active social media use and emotional exhaustion, for example, implies that a positive deviation from an individual's expected level of active social media use will likely be followed by a positive deviation in the individual's expected level of emotional exhaustion at the next occasion in the same direction.

RI-CLPM is statistically equivalent with the traditional cross-lagged panel model, which does not distinguish the within and between levels (Mulder & Hamaker, 2021). Thus, to test whether RI-CLPM fitted the data better than the traditional cross-lagged panel model, a chi-square difference test was conducted. It showed that RI-CLPM had a better fit.

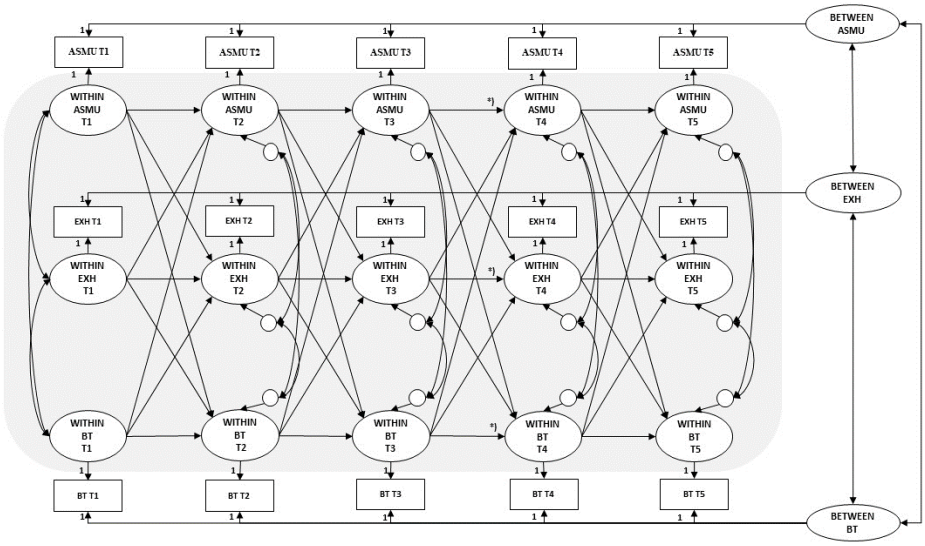

Figure 2. Theoretical random intercept cross-lagged panel model utilized in Study II.

Note: ASMU, active social media use; BT, bedtime on school days; EXH, school-related emotional exhaustion; T1–T5 indicates time measurements (T1, ages 13–14; T2, ages 14–15; T3, ages 15–16; T4, ages 17–18; T5, ages 18–19); *) indicates a 2-year gap in data collection and an educational transition from comprehensive school to upper secondary

Multilevel structural equation modeling with cross-level interaction

In Study III, a multilevel modeling within the SEM framework was utilized, which included multiple regressions in a single model. Multilevel modeling is common for the purposes of investigating intra-individual variation (MSEM; Muthén & Muthén, 1998-2017). With multilevel SEM, a model can be specified for each level of the multilevel data (i.e., individual level, day level) and observation non-independence can be accounted for. Multilevel SEM also allows random intercepts and random slopes to vary across individuals. In Study III, the within level represented within-person associations (i.e., days) and the between level represented between-person associations (i.e., participants). The slopes of the within level were modeled as randomly varying between individuals. This means that the independent variables were allowed to have various effects (i.e., regression coefficients) for each individual. Predictor variables were cluster-mean centered for the within level and group-mean centered for the between level (Hamaker & Grasman, 2015).

In addition, intra-class correlation coefficients were estimated in Study III to define the proportion of variance at each level of interest (students and days). Intra-class correlations estimated how much of the variation is explained at the individual level and how much variation is explained at the day level (Hox, 2013). High enough intra-class correlations supported the multilevel approach.

Cross-level interactions were added to the multilevel models based on the statistically significant random slopes found on the within level. Therefore, the cross-level interaction in Study III examined whether the daily associations between evening social media use and next-day tiredness differ between those who report more than average (+ 1SD) social pressure to remain available online or related availability stress and those who report less than average experiences (- 1SD).

Narrative review

A narrative review was conducted in Study IV. Review articles play an increasingly important role in construing original studies, as the size of the published scientific literature has increased exponentially during the past decades (Byrne, 2016). Narrative literature reviews are qualitative in nature and synthesize the literature and usually identify the gaps in knowledge from the previous scientific and empirical literature (Davies, 2000). Narrative reviews are comprehensive and cover a wide range of issues within a given topic, but they differ from systematic reviews in that they do not reveal how decisions were made concerning the relevance of studies and the validity of the included studies (Collins & Frauser, 2005). As such, reviewers may selectively ignore or limit the attention paid to certain studies to make a point (Davies, 2000). Therefore, in this approach, compared to systematic literature reviews, the selection of information from primary articles is more subjective. Despite these limitations, narrative reviews can be very useful for gathering literature in a specific subject area and synthesizing it. In addition,

narrative reviews can inspire research ideas by identifying gaps or inconsistencies in a body of knowledge (Baumeister & Leary, 1997), thus helping researchers determine research questions or formulate new hypotheses. Narrative reviews are, therefore, valuable in demonstrating the value of a particular viewpoint.

4 Overview of the main findings from the original studies

Q1: How are different forms of socio-digital engagement associated with sleep and academic wellbeing at different developmental phases during adolescence?

Findings from Study I

Study I showed differences in the associations between socio-digital engagement, sleep quality, and academic well-being between girls and boys in early adolescence (ages 12–13 years). Certain mean differences between genders were additionally observed in various domains of socio-digital engagement, sleep duration, and academic well-being (see Table 4). There were no statistically significant differences in friendship-driven or entertainment-driven socio-digital engagement, but girls' knowledge-driven socio-digital engagement was statistically significantly higher than boys' engagement. Mean differences were found in all three categories of digital gaming. Girls reported more time spent playing recreational games than boys did. On the other hand, boys reported more time spent playing action and sport games than girls did. Boys reported slightly higher sleep duration than girls, but no statistically significant differences were observed between girls and boys in perceived sleep quality or bedtimes. Regarding academic well-being, boys and girls differed only in cynicism: boys reported more cynical feelings related to school than girls did.

Table 4. Means, standard deviations, and gender differences from Study I.

	GIRLS	BOYS			
	mean(sd)	mean(sd)	scale	*t*	df
Socio-digital engagement					
Friendship-driven	3.95 (1.52)	3.80 (1.54)	1–7	-1.37	729
Entertainment-driven	4.83 (1.39)	4.90 (1.29)	1–7	.67	725
Knowledge-driven	2.59 (1.22)	2.37 (1.12)	1–7	-2.50*	725
Digital gaming					
Recreational gaming	2.26 (.94)	1.98 (1.08)	1–7	-3.63***	700
Sport gaming	1.62 (.94)	2.95 (1.34)	1–7	15.41**	702
Action gaming	1.59 (.88)	2.96 (1.37)	1–7	16.01***	704
Sleep					
Sleep quality index	6.27 (1.67)	6.49 (1.66)	0–9	1.66	641
Perceived sleep quality	3.08 (.65)	3.09 (.66)	1–4	-.32	673
Perceived sleep duration	8.42 (1.04)	8.66 (1.02)	open reports	-.3.10**	704
Perceived bedtime	22.26 (.84)	22.27 (.87)	open reports	-.19	732
Academic well-being					
Emotional exhaustion	2.60 (1.11)	2.50 (1.08)	1–6	-1.25	745
Cynicism	2.17 (1.17)	2.37 (1.30)	1–6	2.24**	744
Inadequacy	2.53 (1.26)	2.65 (1.33)	1–6	1.18	742
Schoolwork engagement	4.50 (1.43)	4.42 (1.40)	1–6	-.79	744

Note. ***= p < .001, **= p < .01, *= < .05

The associations between socio-digital engagement, sleep, and academic well-being differed between girls and boys in early adolescence (see Figure 4). The findings indicated that friendship-driven socio-digital engagement and playing action games were associated with poorer sleep quality among girls, but, interestingly, playing sport games was associated with better sleep quality among girls. Entertainment-driven socio-digital engagement was associated with worse sleep quality among boys. Other types of socio-digital engagement were not associated with sleep quality among boys.

Further, among girls, friendship-driven socio-digital engagement was positively associated with emotional exhaustion and inadequacy as a student. Among girls, entertainment-driven socio-digital engagement associated with lower school engagement and higher cynicism towards school, and knowledge-driven socio-digital engagement with higher schoolwork engagement and lower emotional exhaustion. Among boys, knowledge-driven socio-digital engagement also associated with lower emotional exhaustion, but with higher feelings of inadequacy as a student. Related to gaming, playing action games was associated with higher

emotional exhaustion, inadequacy as a student, and cynicism towards schoolwork among boys. For both genders, sleep quality was associated negatively with all dimensions of school burnout and positively with school engagement.

Figure 4. Associations between socio-digital engagement (SDE), digital gaming, sleep quality, and academic well-being in early adolescence (Study I).
Note. *** = p < .001, ** = p < .01, * = p <.05

Finally, the findings indicated that statistically significant indirect effects occurred among girls from friendship-driven socio-digital engagement and playing action, and sport games and academic well-being through sleep quality. A statistically significant indirect effect was found between friendship-driven socio-digital engagement and all domains of academic well-being (emotional exhaustion: β=.10, $p < .001$; cynicism: β= .15, $p < .001$; inadequacy: β= .10, $p < .001$; schoolwork engagement: β= -.13, $p < .001$), indicating that more frequent friendship-driven socio-digital engagement associated with lower academic well-being through lower sleep quality among girls in early adolescence. In addition, the findings indicated that sleep quality partly mediated the link between sport and action gaming and school burnout among girls. Playing action games associated with poorer sleep quality and a statistically significant indirect path from action gaming to higher emotional exhaustion (β= .11, $p < .01$), cynicism (β = .16, $p < .001$) and inadequacy (β = .10, $p < .001$) through worse sleep quality. Playing sport games showed opposite results. Among girls, playing sport games associated with better sleep quality, and the indirect effects of sport gaming on emotional exhaustion (β= -.09, $p < .01$), cynicism (β = -.14, $p < .001$), and inadequacy (β = -.09, $p < .001$) were statistically significant and negative. This suggests that better sleep quality weakened the association between sport gaming and lower academic wellbeing among girls.

Among boys, the statistically significant indirect paths were related to entertainment-driven socio-digital engagement. Among boys, entertainment-driven socio-digital engagement was associated with poorer sleep quality, and the indirect paths to emotional exhaustion (β= .05, $p < .05$), cynicism (β = .06, $p < .01$), and inadequacy (β = .05, $p < .01$) were positive while being negative to schoolwork engagement (β= -.07, $p < .01$). The direct paths were statistically non-significant. This indicated that entertainment-driven socio-digital engagement was associated with lower academic well-being among boys through lower sleep quality in early adolescence.

To sum up, these findings from Study I indicated that the associations between socio-digital engagement, sleep, and academic well-being differed regarding gender as well as the type of socio-digital engagement. In addition, perceived sleep quality explained parts of the variation. Based on Study I, the associations between socio-digital engagement and academic well-being were concluded to be partly mediated by sleep quality (supporting the sleep displacement hypothesis), but socio-digital engagement may also associate with academic well-being through the energy-depleting and motivational processes (the direct effects). The results of Study I indicated that, for both genders, knowledge-driven socio-digital engagement could potentially have a positive impact on academic well-being. Friendship-driven socio-digital engagement for girls and entertainment-driven socio-digital engagement for boys can have a negative impact on sleep quality, which may further harm academic well-being.

Study I was a cross-sectional study and did not allow deeper inferences regarding the direction of the effects. Therefore, Study II examined sleep displacement and the energy-depleting process at a deeper level and focused on longitudinal reciprocal associations and the links between friendship-driven socio-digital engagement, bedtimes, and school-related emotional exhaustion.

Findings from Study II

Study II focused on active social media use that was defined as friendship-driven socio-digital engagement. In addition, the focus was especially on emotional exhaustion, which is one dimension of school burnout. Further, bedtimes were included in the models to control for the role of delayed bedtime. Study II showed that no consistent longitudinal or cross-sectional patterns between increased active social media use, increased emotional exhaustion, and delayed bedtimes across the years of adolescence. This means that the associations varied across the different years of adolescence. Figure 5 shows the intra-individual associations from the Random Intercept Cross-Lagged Panel Model.

On the within level, increased active social media use and delayed bedtimes were found to associate with each other only in early adolescence, when adolescents were aged 13–14 years. This indicated that, in early adolescence, when the participants reported higher-than-usual active social media use (compared to each individual's personal mean across the study), they also reported later-than-usual bedtimes. Further, increased active social media use and increased emotional exhaustion were positively associated in both middle (ages 14–15) and late adolescence (ages 17–18). This indicated that during these years, when adolescents reported higher-than-usual active social media use, they also reported higher-than-usual emotional exhaustion. Last, at the ages of 17–18 years, increased (higher-than-usual) emotional exhaustion associated with later-than-usual bedtimes. The longitudinal findings indicated that increased active social media use at the ages of 14–15 years predicted increased emotional exhaustion one year later. No other longitudinal associations were found.

On the between level, the associations between active social media use, emotional exhaustion, and bedtimes were non-significant, indicating that those adolescents who reported more active social media use, on average across the years of adolescence, did not report more emotional exhaustion or later bedtimes. Gender was controlled for as a robustness check, but the interpretation of the model estimates did not change, which indicated that gender did not influence the associations in this model. Additionally, these results showed that the associations between socio-digital engagement, sleep, and academic well-being varied at different levels, including the between-person and within-person levels.

To conclude, these findings further shed light on the complex effects of socio-digital engagement on academic well-being and sleep. Certain results from Study

I were replicated in Study II, indicating consistency and supporting the robustness of the results: friendship-driven socio-digital engagement was associated with later bedtimes in early adolescence. Interestingly, active social media use was not associated with later bedtimes later in adolescence (14–19 years). The findings showed that the associations were not consistent throughout the years of adolescence, and that the intra-individual effect sizes between adolescents' active social media use, emotional exhaustion, and bedtimes were small to moderate.

Study II employed a longitudinal design with one-year time lags between measurement points. In Study III, the identified intra-individual associations were further investigated in late adolescence to delve deeper into the short-term (daily-level) effects of friendship-driven socio-digital engagement on sleep and academic well-being.

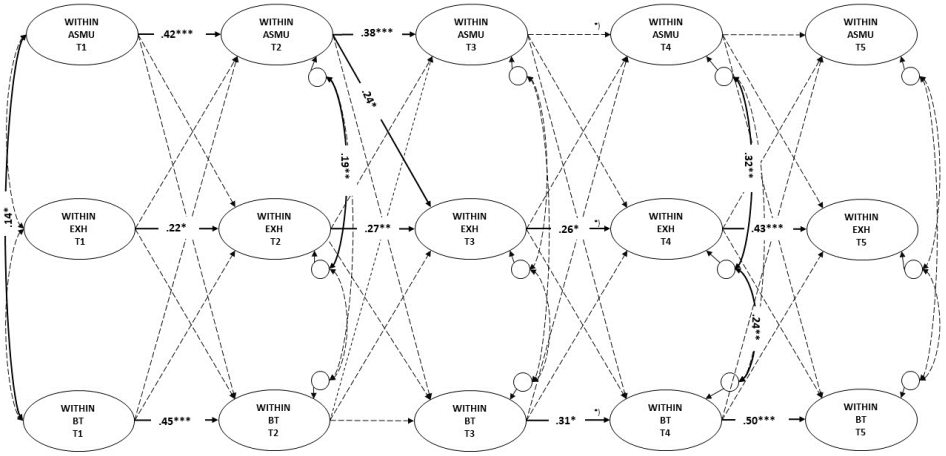

Figure 5. Random Intercept Cross-lagged Panel Model from Study II that examined the longitudinal and reciprocal intra-individual associations (within level) between active social media use (ASMU), emotional exhaustion (EXH), and bedtimes (BT) across the years of adolescence (from ages 13–14 to ages 18–19).

Note: The broken lines represent non-significant associations, and the solid lines represent significant associations. *** = p < .001, **= p < .01, *= p < .05.

Findings from Study III

In Study III, the complex associations between socio-digital engagement, sleep, and academic well-being were further investigated on a daily level in late adolescence (17–18-year-olds). Across a two-week study period, bedtimes were objectively measured and academic well-being was assessed multiple times per day through momentary feelings of tiredness, stress, and anxiety during school days. Study III replicated findings from Study II by demonstrating that pre-bedtime friendship-driven socio-digital engagement, both active and passive social media use, did not associate with later bedtimes in late adolescence. Actually, pre-bedtime active social media use associated with earlier bedtimes and better sleep quality (see Figure 6). More specifically, on the evenings that adolescents reported active social media use, earlier bedtimes were also recorded with the activity bracelets (within-level association). In addition, those adolescents who reported, on average, active social media use close to bedtime across the study, also reported better sleep quality (between-level association). Moreover, those who reported, on average, passive social media use close to bedtime, were recorded with earlier bedtimes across the study (between-level association). In addition, pre-bedtime active social media use was associated with lower levels of tiredness at school the following day (within-level association, see Figure 7). Pre-bedtime passive social media use did not associate with next-day tiredness, stress, or anxiety (Figure 7).

To sum up, findings from Study III showed that sending messages with friends and spending time on social media in the evening were associated with earlier bedtimes and less tiredness at the school in late adolescence. When measured on a daily level, friendship-driven socio-digital engagement did not associate with lower academic well-being in late adolescence, which was contrary to what Study II indicated.

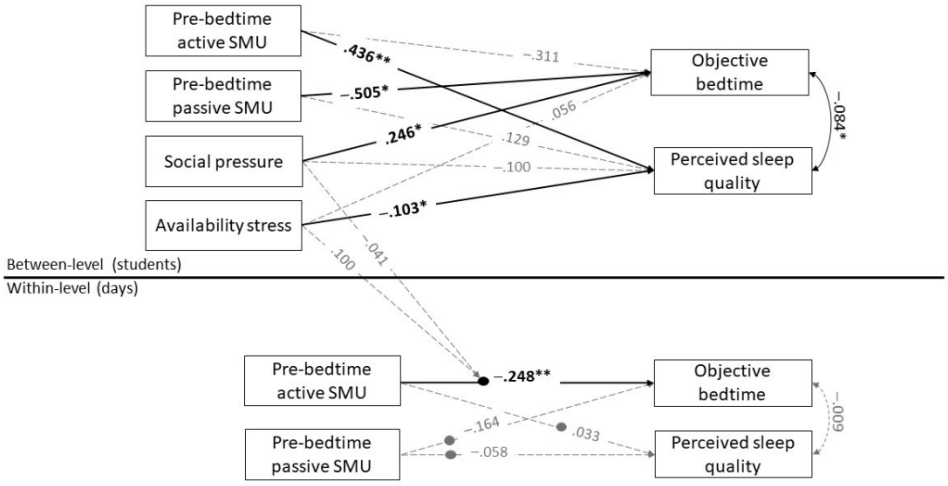

Figure 6. Multilevel SEM with cross-level interaction conducted in Study III that investigated the within- and between-level associations of active and passive social media use (SMU), objective bedtimes, and perceived sleep quality. Note: Broken lines represent non-significant associations, and solid lines represent significant associations.

Note: *** = p < .001, **= p < .01, *= p< .05.

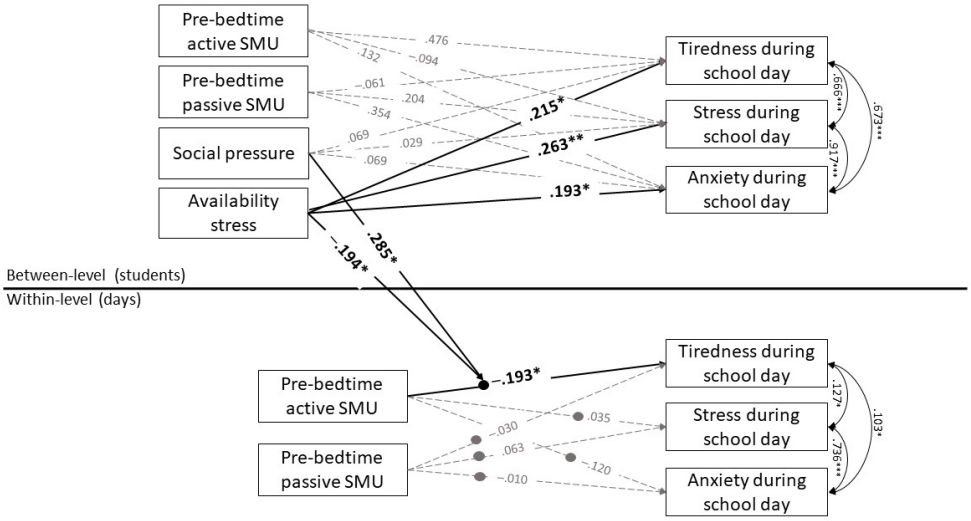

Figure 7. Multilevel SEM with cross-level interaction conducted in Study III that investigated the within- and between-level associations of active and passive social media use, tiredness, stress, and anxiety during school days. Note: Broken lines represent non-significant associations, and solid lines represent significant associations.

Note: *** = p < .001, **= p < .01, *= p < .05.

RQ2: How social pressure and related availability stress moderate the daily links between social media use, sleep, and academic well-being?

Findings from Study III

Findings from Study III further indicated that perceived social pressure was associated with later objectively measured bedtimes and availability stress associated with poorer sleep quality, but also with more tiredness, stress, and anxiety during school days across the study (see Figures 6 and 7). More specifically, those adolescents who reported higher social pressure in the baseline questionnaire were recorded with later bedtimes across the two-week study and those who reported more availability stress also reported worse sleep quality and more tiredness, stress, and anxiety across the study.

Furthermore, Study III investigated the moderating effects of social pressure and availability stress. The within-level association between active social media use close to bedtime and next-day tiredness was moderated by social pressure and availability stress (see Figure 7 for multilevel associations and Figure 8 and 9 for plotted cross-level interaction). The results from cross-level interaction analyses indicated that active social media use in the evening associated with less tiredness only among those adolescents who reported lower social pressure regarding being available online (Figure 8). Among those who reported higher-than-average social pressure, the association between active social media use and tiredness was close to zero. The moderation effect related to availability stress also showed interesting results: participants who reported higher-than-average availability stress, also reported, on average, more tiredness (Figure 9). However, for these participants, the association between pre-bedtime active social media use and next-day tiredness was negative. Among those who reported less availability stress, the association between active social media use and tiredness was close to zero. These findings suggested that measures that do not focus solely on time spent online or the frequency of use, but that rather measure how individuals perceive specific features of socio-digital engagement, could bring out different effects.

Based on the results from Study III, friendship-driven socio-digital engagement itself may not be that harmful in late adolescence for sleep or well-being at school, but the related experiences of social pressure and related stress may have more negative effects. The results further supported the findings from Studies I and II that the mechanism behind the effects of socio-digital engagement can be very multidimensional, the effects can vary according to context, and social as well as individual differences are important for emphasizing when the interplay between socio-digital engagement, sleep, and academic well-being are investigated.

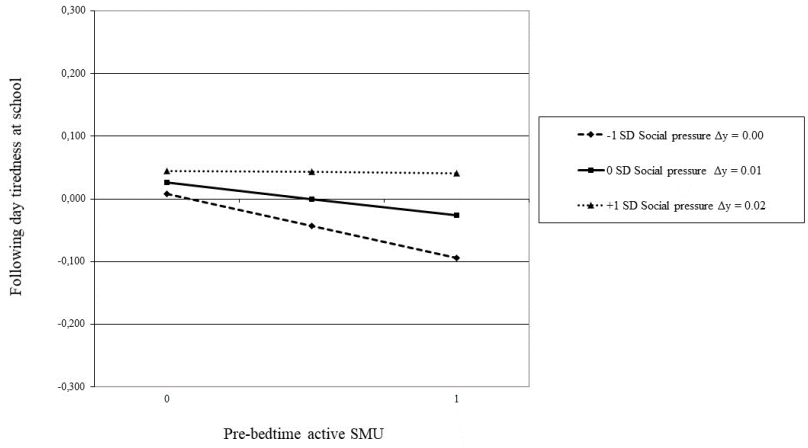

Figure 8. Plotted cross-level interaction for social pressure from multilevel model conducted in Study III that modeled pre-bedtime active social media use and next-day tiredness during the school day.

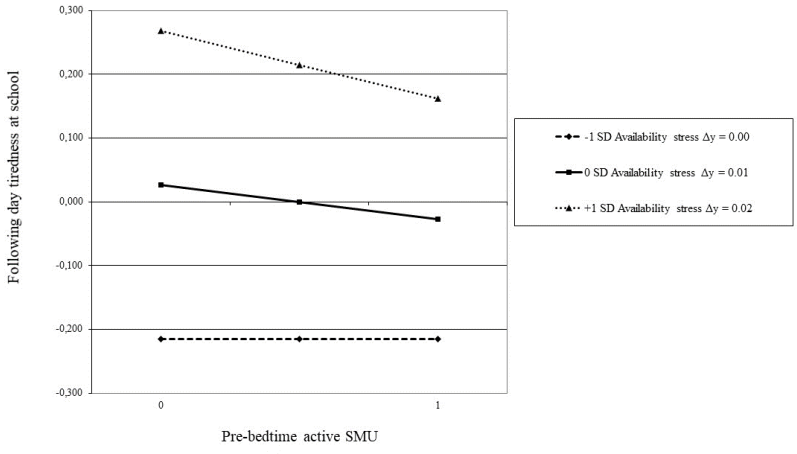

Figure 9. Plotted cross-level interaction for availability stress from multilevel model conducted in Study III that modeled pre-bedtime active social media use and next-day tiredness during the school day.

RQ3: In light of developmental and contextual factors, how can we conceptualize the processes linking socio-digital engagement and academic well-being?

Findings from Study IV

Study IV was a narrative review addressing the continuities and discontinuities between engagement with digital media and academic well-being for school-aged children and young people. Following the examination of the current literature, the conclusion was that, in general, the field of "digital media effects" needs to move beyond the concept of screen time and utilize the research that has already been conducted on students' multidimensional socio-digital engagement. The average effects of socio-digital engagement on academic well-being and performance were also concluded to be negligibly small but concurrently heterogeneous, further corroborating the claim to examine the qualitative differences in students' socio-digital engagement, individual differences between students, and contextual interplay.

Based on the review (and Studies I and II, both of which had been conducted by the time the review was written), The Developmental-Contextual Model of Digital Demands and Resources (DC-DDR; see Figure 10) was introduced as a result in Study IV. The DC-DDR model outlined that the effects of socio-digital engagement on academic well-being can be approached through the theoretical framework of the school demands-resources model (Salmela-Aro & Upadyaya, 2014). The DC-DDR model, however, was adjusted for socio-digital engagement rather than school engagement. The DC-DDR asserts that the possible negative outcomes from socio-digital engagement result from an imbalance between the psychological or social demands that arise from socio-digital engagement and the personal resources available to overcome these demands. Demands that arise from various types of socio-digital engagement require psychological effort and are consequently related to psychological costs. On the other hand, resources are features that are functional in achieving personal goals responding to the demands and reducing the psychological costs associated with them. The DC-DDR emphasizes that developmental phase and contextual factors influence how individuals engage socio-digitally and whether this engagement functions as a resource or a demand. In addition, various socio-digital practices can indirectly increase other resources or demands that can additionally influence academic well-being.

In line with the school demands-resources model, DC-DDR emphasizes that the imbalance between the available socio-digital resources and demands can be approached through two overlapping processes: the energy-depleting process and the motivational process. The energy-depleting process is linked to overtaxing and wearing out due to heavy demands that exhaust energy. In relation to socio-digital engagement and academic well-being, this process may occur if socio-digital en-

gagement takes too much time and/or effort, simultaneously displacing other important activities that promote academic well-being, such as delaying bedtime. Practices of socio-digital engagement that negatively influence sleep may lead to increases in the daily demands at school at a certain age, which can consequently lead to lower academic well-being. The motivational process, in turn, refers to situations where a lack of sufficient resources hinders dealing effectively with heavy demands, which may lead to disengagement or foster mental withdrawal. The motivational process may also occur if the informal socio-digital practices are not consonant with the formal digital practices in place at school. Among digital natives, informal digital practices (i.e., how they use social media) are often more advanced than formal digital practices, yet informal practices are often not acknowledged in the school environment and thus do not contribute to the sense of competence in the school context.

In line with other media effects theories, the DC-DDR states that similar engagement online can constitute a resource for one person and a demand for another due to pre-existing conditions and susceptibilities. The DC-DDR also emphasizes the developmental phase of students that moderates the effects of socio-digital engagement. Therefore, the effects and outcomes of socio-digital engagement should be viewed in relation to an adolescent's developmental stage, and the key challenges should be related to that developmental stage.

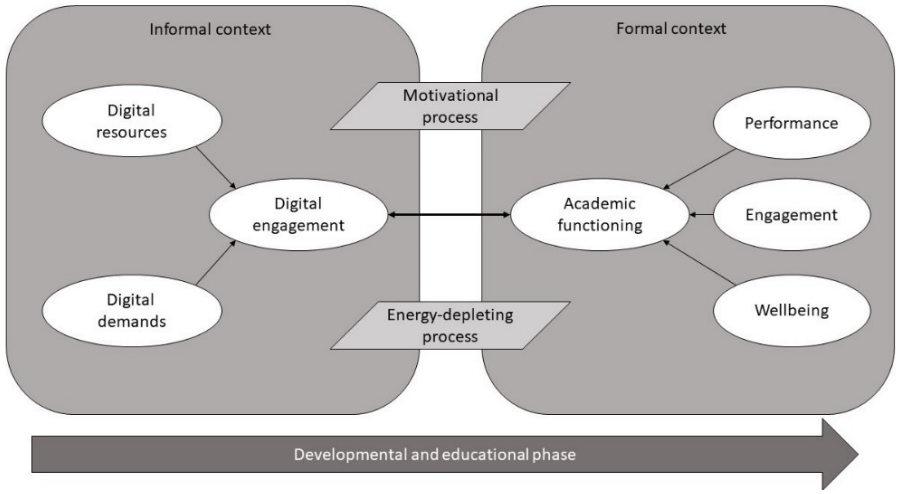

Figure 10. The Developmental-Contextual Model of Digital Demands and Resources introduced in the narrative review conducted in Study IV.

5 Discussion

In this section, I will discuss my dissertation's main findings (for a summary, see Table 5) in relation to the research questions posed earlier. I will first focus on the differences in socio-digital engagement effects that occur at various developmental phases across adolescence. Second, I will focus on the sleep displacement hypothesis along with the energy-depleting and motivational processes related to socio-digital engagement and academic well-being. Third, I suggest that balancing between various socio-digital demands and personal resources to tackle the demands is a modern digital skill. Fourth, I discuss the methodological strengths and limitations of this thesis. Last, I argue that adolescents require support from both parents and educational professionals in developing healthy habits related to socio-digital engagement. This support can aid in maintaining a balance between the demands and resources related to socio-digital engagement.

Table 5. Summary of the main findings.

RQ1. How are various forms of socio-digital engagement associated with sleep and academic well-being at different developmental phases during adolescence?	
Study I	• Associations between socio-digital engagement, sleep, and academic well-being differed regarding gender and the type of socio-digital engagement.
	• Knowledge-driven socio-digital engagement was positively associated with academic well-being among both boys and girls.
	• Friendship-driven socio-digital engagement in girls and entertainment-driven socio-digital engagement in boys associated with poor sleep quality.
Study II	• Associations were not consistent throughout the years of adolescence, and the intra-individual effect sizes between increased friendship-driven socio-digital engagement, increased emotional exhaustion, and delayed bedtimes were small to moderate.
	• Increased friendship-driven socio-digital engagement associated with later bedtimes in early adolescence (in line with Study I).
	• Increased friendship-driven socio-digital engagement associated with increased emotional exhaustion in middle and late adolescence.
Study III	• In late adolescence, pre-bedtime friendship-driven socio-digital engagement associated with earlier bedtimes, better sleep quality, and less tiredness during school days.
	• Pre-bedtime friendship-driven socio-digital engagement did not associate with lower academic well-being in late adolescence (contrary to Study II).
RQ2. How social pressure and related availability stress moderate the daily links between social media use, sleep, and academic well-being?	
Study III	• Social pressure to remain accessible to others associated with later bedtimes.
	• Stress related to social pressure to remain accessible to others associated with poor sleep and higher levels of tiredness, stress, and anxiety.
	• Social pressure and related stress moderated some of the daily relationships.
RQ3. In light of developmental and contextual factors, how can we conceptualize the processes linking socio-digital engagement and academic well-being?	
Study IV	• The average effects of socio-digital engagement on academic well-being and performance in the existing literature are negligibly small but also heterogeneous.
	• The qualitative differences in students' socio-digital engagement, the individual differences between students, along with the developmental and educational phases should be considered in future studies.
	• The imbalance between the available socio-digital resources and demands can be approached through two overlapping processes: the energy-depleting process and the motivational process.

5.1 Developmental and educational phase matters

One of the main arguments of this thesis is that the associations between socio-digital engagement, sleep, and academic well-being differ according to adolescent age, which is in line with earlier literature (see for example Orben & Blakemore, 2023; Valkenburg & Peter, 2013). This is not solely a matter of physical age but is related to both developmental and educational factors. Developmental factors encompass various aspects of individuals' developmental tasks during adolescence, such as forming connections with peers, dealing with social rejection, and fitting into peer groups (see for example Blakemore, 2018; Sawyer et al., 2012). Developmental factors also relate to sleep, which faces biological changes during adolescence (Darchia & Cervena, 2014; Exelmans & Van den Bulck, 2019). However, adolescence lasts for several years, during which these biological changes settle down, meaning that individuals in the early stage of adolescence differ from adolescents in the late stage (Darchia & Cervena, 2014). On the other hand, educational factors relate to academic well-being. In Finland, academic well-being decreases especially when entering upper secondary school and well-being decreases are more common among girls than among boys (see for example Read et al., 2022; Salmela-Aro & Tynkkynen, 2012). School pressure is also common during adolescence (Núñez-Regueiro & Núñez-Regueiro, 2021). Therefore, the associations between socio-digital engagement and academic well-being can vary across different educational phases. Furthermore, as adolescents progress through late adolescence, they typically experience increased autonomy in various domains of life. They have greater freedom in determining their own bedtimes and how they allocate their free time. Additionally, during late adolescence, schoolwork frequently requires a greater level of independent contribution compared to early adolescence.

When studying the effects of socio-digital engagement on adolescent sleep and academic well-being, considering these educational and developmental factors is crucial (Orben & Blakemore, 2023) because of two reasons. First, age can work as a moderator (see for example Valkenburg et al., 2016), which was also evident in the original studies conducted for this thesis: the associations between socio-digital engagement, sleep, and academic well-being differed in early, middle, and late adolescence. Second, developmental and educational factors also influence how and why adolescents engage online. This often means that individuals typically prefer to digitally engage in media content that is only moderately discrepant from their age-related comprehension experiences (Valkenburg & Peter, 2013). Related to adolescence development and increased autonomy, socio-digital engagement in adolescence can act as an environment where adolescents experience a sense of autonomy (Parent, 2023), which may further motivate them to spend time online interacting with peers and out of sight of their caretakers.

With age, adolescents also develop more self-regulative skills through increased digital experiences (Vissenberg et al., 2022). Therefore, younger adolescents can be more vulnerable to the effects of socio-digital engagement if they lack the self-regulation skills required to manage various socio-digital demands. This can potentially lead to the development of unhealthy habits related to socio-digital engagement. Social media platforms are often restricted to over 12–13-year-olds; therefore, it is possible that the novelty effect for younger adolescents will lead to an overuse or problematic use of social media. Over time, the novelty value of the applications decreases, and older adolescents also develop routines and practices to handle and regulate their digital media use. As digital possibilities evolve, so do the habits and skills related to socio-digital engagement (Vissenberg et al., 2022). That said, the resources for coping with the digital demands and for regulating personal digital behavior in relation to sleep and academic demands may be better with increasing age.

Reflecting on the findings of the original studies is interesting based on these developmental and educational factors. In Study II, the associations between active social media use, emotional exhaustion in schoolwork, and bedtimes were investigated longitudinally, focusing simultaneously on the associations within one measurement point. Interestingly, the increase in active social media use was associated with later bedtimes only in early adolescence. This was in line with findings from Study I, where similar friendship-driven social media use associated with poor sleep quality. In Studies II and III, friendship-driven socio-digital engagement did not associate with delayed bedtimes or poorer sleep quality in late adolescence. On the contrary, friendship-driven socio-digital engagement in Study III was associated with earlier bedtimes and better sleep quality. These findings indicate that the older adolescents are, the less friendship-driven socio-digital engagement in particular is related to later bedtimes or poor sleep quality. Therefore, the sleep displacement hypothesis should be reflected through the developmental phase of the adolescents and should take the context of socio-digital engagement into account. Findings of this thesis align with earlier literature (Bartel & Gradisar, 2017; Das-Friebel et al., 2020; Harbard et al., 2016; Siebers et al., preprint; Tkaczyk et al., 2023), which has also emphasized similar kind of study design (i.e., experience samling method) and suggested that social media use is not associated with later bedtimes or poor sleep quality. However, it is essential to note that experience sampling studies often span only a few days or at most weeks. Therefore, we cannot know about the longer-term trend, i.e., whether the use of digital media has shifted bedtime to a later time within individuals.

In terms of academic well-being, Studies I and II showed that friendship-driven socio-digital engagement associated with lower academic well-being in early, middle, and late adolescence (in Study I this applied to girls only). However, the effect size of Study II was much stronger in late adolescence than in middle ado-

lescence. This can be explained by educational factors (such as increasing schoolwork towards upper secondary school) but also by the fact that participants in late adolescence reported more social media use. This may be due to social media platforms being more developed since the beginning of Study II (a follow-up study) and because parental influence may be lower than in middle adolescence. Emotional exhaustion related to schoolwork was also higher in late adolescence, which is in line with earlier findings from Finland (Read et al., 2022). In addition, increased emotional exhaustion in late adolescence also associated with later bedtimes. This suggests that this period of life may be more stressful and pressured in general, potentially leading to distinct effects of socio-digital engagement.

Interestingly, Study III did not replicate findings from Study II, despite Study III using a subsample from Study II (timepoint 4). Data for timepoint 4 in Study II was collected the same spring as the data collection for Study III was conducted. However, the results were opposite between these two studies. This may be due to two reasons. First, the measures of socio-digital engagement, sleep, and academic well-being were different between the studies. Second, the study designs (time scales) were different between the studies. Study II was a yearly survey study focusing on long-term effects, and Study III was an ESM study examining the short-term effects on a daily level (the methodological viewpoints related to these contrary results are discussed in more detail in section 5.5 Methodological reflections). Based on the contradictory findings, it can be concluded that how and when socio-digital engagement is being measured influence the observed effects. That said, and also suggested by the DC-DDR model (Study IV), it is important to focus on how and in what kind of developmental phases and contexts socio-digital engagement and academic well-being are measured, as these can bring out different effects.

5.2 Friendship-driven socio-digital engagement and the energy-depleting process

This dissertation did not find strong evidence showing that reduced sleep is the key factor contributing to the associations between socio-digital engagement and academic well-being (i.e., the sleep displacement hypothesis). However, the original studies showed interesting links between friendship-driven socio-digital engagement and academic well-being that could not be explained by later bedtimes or poor sleep quality. Study I suggested that friendship-driven socio-digital engagement was associated with higher emotional exhaustion in early adolescence. However, Study II did not replicate this finding, which may be due to the more sophisticated statistical analysis in Study II compared to Study I (see more in sec-

tion 5.5 Methodological reflections). In Study II, increased friendship-driven socio-digital engagement associated with increased schoolwork-related emotional exhaustion in middle and late adolescence. Study III, however, did not replicate that friendship-driven socio-digital engagement was associated with lower well-being during school days. However, availability stress related to socio-digital engagement associated with lower academic well-being in Study III. These associations can be, as suggested in the DC-DDR model (Study IV), reflected through the energy-depleting process.

The energy-depleting process links to overtaxing and wearing out due to heavy demands that exhaust energy. In relation to socio-digital engagement and academic well-being, this process may occur if socio-digital engagement takes too much time and/or effort, simultaneously displacing other important activities that promote academic well-being. In the literature, these types of associations are often referred to as the Goldilocks hypothesis, which several empirical findings have supported (see for example Boniel-Nissim et al., 2023; Hisler et al., 2020; Lahti et al., 2021; Przybylski & Weinstein, 2017). However, this refers to time spent online and that non-users or excessive users show lower well-being than normative users.

The DC-DDR model suggests, as an addition to the Goldilocks hypothesis, that the association between informal socio-digital engagement and academic well-being can occur if socio-digital demands and resources are imbalanced. It is connected not only to behavioral factors (i.e., amount of time spent online) but also to various psychosocial factors. In Study III, social pressure and related stress were examined as indicators of social norms requiring constant availability. Thus, based on the findings from Study III, social pressure related to socio-digital engagement can be proposed to be exhausting to some adolescents or may increase the demands in daily life that exhaust energy. This is in line with earlier literature (see for example Steele et al., 2020), showing that how socio-digital engagement is perceived may be more important than the time spent online or the usage type. Interestingly, but in line with earlier studies (Hall, 2017; Thomée et al., 2011), perceived social pressure and availability stress in Study III were not strongly associated with social media use itself. This indicates that how much time is spend engaging online or when may not reveal the whole picture, but rather, the psychosocial experiences of various dimensions of the "always-on" culture complement these complex associations.

In line with the DSMM framework (Valkenburg & Peter, 2013), DC-DDR also emphasizes the differential susceptibility to digital media effects. Other adolescents are more vulnerable to social demands and are more affected by the constant connection overload and socio-digital stimuli. This dissertation did not explore the variations in individuals' perceptions of social demands or the resources they possess for coping with these demands. However, Study III revealed intriguing

findings that are relevant to this aspect. Adolescents who reported more availability stress, also reported more tiredness. Interestingly, however, sending messages with friends in the evenings showed itself to be associated with less tiredness the next day for this group. This may indicate that adolescents relieve this type of availability stress by being in contact with friends. Therefore, sending messages with friends can work as a beneficial coping habit to some individuals. Adolescents that have friends they can send messages to and whom they perceive important to be accessible to, have social connections that are generally beneficial for well-being during adolescence. In the literature, this is often referred to as the rich-get-richer hypothesis (see for example Kraut et al., 2002), which means that adolescents with rich existing offline social connections benefit more from social media use than those with fewer or poor-quality offline friendships. On the other-hand, more socially vulnerable youths may use the Internet to complement, rather than replace, offline interactions and relationships (Scott et al., 2021). This finding can also connect to experiences of fear of missing out (FoMO), as noted, for example, by Przybylski et al. (2013). Staying in contact with friends and being aware of their activities may help alleviate these FoMO experiences. However, it is probable that a vicious cycle is formed, rendering it challenging for individuals to break free. This difficulty may be particularly pronounced during adolescence, when peer acceptance holds significant importance.

To conclude, the energy-depleting process can relate to the displacement of other activities that increase energy (i.e., recovery or sleep) but also to social demands and constant social connection to others that, for some individuals, may exhaust energy. Thus, instead of solely emphasizing the duration of engagement in various socio-digital activities, future research should shift its focus towards exploring the emotions and experiences generated by these activities, along with identifying individual differences in relation to these. A further avenue of exploration is how these can promote or hinder various domains of well-being.

5.3 Interest-driven socio-digital engagement and the motivational process

The original studies of this thesis focused more on friendship-driven socio-digital engagement and the energy-depleting process. However, Study I showed some interesting results related also to the motivational process proposed in the DC-DDR model. Findings from Study I suggested that socio-digital engagement, especially among boys, was not associated with academic well-being through lower sleep quality, but a direct link was found. In Study I, adolescents who reported more knowledge-driven socio-digital engagement also reported lower academic well-being. Earlier literature suggests that this may be because adolescents' digital

skills and desires for using these skills in the school context are not acknowledged and schools alienate students and decrease their academic well-being, thus increasing disengagement towards schoolwork (see for example Hietajärvi et al., 2020).

Adolescents live in a hybrid world, where the online and offline worlds are entangled. What happens outside the school context and during adolescents' leisure time influences the domains of life in formal school contexts. Socio-digital engagement that happens in informal contexts is often very different from how adolescents are allowed to engage digitally in school contexts. The motives for engagement differ, and teachers are the ones who often decide how adolescents engage digitally in the formal contexts at school. Outside of school, engagement is more about social connections while at school it is more about using digital platforms as tools for finishing learning tasks.

These motivational processes should be further investigated in relation to the increase in school pressure and academic ill-being. Future studies could focus on adolescents who are disengaged from schoolwork and investigate how the educational system could engage these students further with the help of pedagogically meaningful digital solutions. For some, integrating elements from adolescent ways of engaging online during leisure time may increase the interest felt towards formal learning (Halonen et al., 2016).

5.4 Finding a balance between digital resources and demands is a modern digital skill

In this dissertation I suggest that, in addition to investigating how and when adolescents engage in various digital platforms, research should move forward to examine the various perceptions of socio-digital engagement and individual differences in these. In this dissertation, I suggest that, by investigating each of these aspects together, a more comprehensive understanding of adolescent socio-digital engagement and its influence on well-being could be attained. This is due to adolescents living in a hybrid world, where the online and offline worlds collide (Granic et al., 2020). Therefore, an individual's online self is also linked to offline mental health and well-being (Vorderer et al., 2017), and pressure to remain accessible to others (Steele et al., 2020) is not only tied to socio-digital engagement but is also concerned with social norms and habits.

The DC-DDR model suggests that an imbalance between digital resources and demands can end up decreasing academic well-being. This imbalance can occur through numerous reasons, which are described in the DC-DDR model as the energy-depleting and motivational processes. Academic well-being is affected by

the imbalance that occurs between various psychological, social, and physical resources and challenges/demands (Salmela-Aro & Upadyaya, 2014). I suggest that finding a balance between the resources and demands (by using various coping, self-regulating, and socio-emotional skills) can be considered to be modern digital skills in addition to more practical and technical digital skills, which surely are also important. Regardless, it is imperative that adolescents are not left to navigate these skills on their own. Rather, it is crucial for parents and schools to play an active role in teaching and guiding them.

These types of digital skills can contribute to young people's skills of coping effectively with online experiences and hence protect their well-being. As suggested by Vissenberg et al. (2022), the focus lies on online resilience, which pertains to the ability to recover and "bounce back" from negative experiences and emotions encountered in the online environment. Adolescents are, however, in differing positions because some adolescents have more self-control (Casey & Caudle, 2013; Willems et al., 2019). This means that others are more susceptible, and socio-digital engagement can influence their dimensions of well-being more negatively and more strongly (Valkenburg & Peter, 2013). These self-control skills can protect, for example, from overwhelming social distractions (Siebers et al., 2022b), which in the long run can challenge personal cognitive ergonomics (Alho et al., 2022). Some individuals, however, need more help in developing these skills. The better digital coping skills adolescents have, the better they are equipped to cope with the demands of the digital world (Vissenberg et al., 2022).

Although the original studies from this thesis adopted a perspective where socio-digital engagement was seen as a causal factor affecting adolescents' well-being, I suggest, in line with earlier literature, that individuals' pre-existing conditions and skills play a large role in moderating the effects of socio-digital engagement on sleep and academic well-being (Bartel & Gradisar, 2017; Valkenburg et al., 2016). Other individuals may experience more digital stress and be more harmed by the always-on culture, where everyone needs to be available and responsive almost around the clock. Related to online resilience and bouncing back from negative experiences, Dodge et al., (2012) propose that individuals have a set point for well-being. The effects of socio-digital engagement can be either positive or negative within the same individual, but in the end, well-being returns to a personal set point, just like a seesaw (Weinstein, 2018). Investigating whether the short-term effects are accumulated into long-term effects and which adolescents benefit most from socio-digital engagement and what kind of engagement is most beneficial and to whom (Pouwels et al., 2022) is a way further. This, however, requires sophisticated research methods that are often also time-consuming.

To sum up, adolescents have pre-existing conditions that may explain why some adolescents are more vulnerable to socio-digital media effects than others are (Valkenburg & Peter, 2013). Thus, developing self-regulative coping skills for

balancing between the increasing socio-digital demands and personal resources is a modern skill that will help adolescents navigate in a world of increasing digital opportunities and challenges.

5.5 Methodological reflections

As illustrated in this dissertation, adolescents are not a uniform group in relation to socio-digital engagement. This means that adolescents' habits and attitudes towards socio-digital engagement differ in addition to the motives they have, which are the drivers for why adolescents engage in certain ways on digital platforms. Therefore, research on this topic needs to consider this complexity. One of the main aims in this dissertation was to investigate these processes more deeply, and through the original studies, complexity was considered theoretically but also by using methodological approaches that emphasize the inter- and intra-individual associations (between- and within-person levels). Objective measures were included. This thesis investigated the associations considering gender (Study I and Study II) and age as moderating factors (Study II) and by investigating the links between socio-digital engagement, sleep, and academic well-being in early, middle, and late adolescence (Study I, Study II and Study III). In addition, longitudinal study designs were implemented to better investigate the between-person and within-level associations (Study II and Study III). These longitudinal associations were examined with different temporal focuses by emphasizing long- and short-term effects. Finally, a new contextual model related to adolescents' socio-digital engagement and academic well-being was introduced (Study IV).

However, this thesis also had some limitations that should be considered in future studies. One limitation is that the data sampling was based on convenience sampling. Participants that were willing to participate were included. Because of this, the results of the original studies should be viewed carefully, and generalizations should be avoided (Johannes et al., 2021a, preprint). It is likely that the individuals who had the resources, energy, and interest to participate are adolescents who are generally doing well in life, and those who have challenges in life are not included in the studies. Therefore, the results of this thesis are more likely to correspond to adolescents that are not at risk of severe mental health problems and do not have very challenging situations in their offline lives.

Studying the specific types of socio-digital engagement is equally important as exploring the overall impact it has on adolescent well-being, highlighting the significance of understanding both aspects. By separating the various dimensions of socio-digital engagement, researchers can better understand the nuances of how individuals engage online and how it affects them (Valkenburg et al., 2022b). This thesis focused on normative socio-digital engagement. Though it was a strength

to separate the various dimensions of socio-digital engagement, this thesis did not investigate the effects of media multitasking or problematic social media use on adolescent sleep and academic well-being. Existing literature suggests that media multitasking is associated with distractability (see for example Baumgartner et al., 2018; Moisala et al., 2016) along with sleeping problems (see for example Van der schuur et al. 2015), which all may further impact adolescent well-being and performance at school. Future studies should therefore focus on examining what kind of socio-digital habits (for example, engaging with multiple devices simultaneously) are risk factors for academic well-being. Here again, considering age and other individual factors along with reciprocal associations.

Socio-digital engagement is a broad concept, and the effects of socio-digital engagement on sleep and well-being should be viewed through multidimensional lenses. In the original studies, this multidimensionality was considered in several ways. In Study I, the dimensions of socio-digital engagement, both friendship-driven and interest-driven engagement, were considered and the effects on sleep quality and academic well-being were examined. However, Study I was a cross-sectional study, which surely was a limitation. It is impossible to infer any causal relationships based on Study I. In Study II, the causal relationships were better considered by modeling the intra-individual reciprocal associations longitudinally. This was a strength, but on the other hand, Study II only investigated friendships-driven socio-digital engagement and not any other dimension of socio-digital engagement. Future studies should therefore examine how, for example, digital gaming or other interest-driven social media use associate with bedtimes and academic well-being across the adolescent years. However, examining friendship-driven socio-digital engagement only was a considered decision, and our meaning was to be as precise as possible and not to sum up all socio-digital engagement into one construct, which has been done previously in many studies, for example by using overall screen time measurements. The aim in Study II was to focus particularly on friendship-driven engagement and the energy-depleting process. However, one limitation related to longitudinal associations in Study II was that the data were collected yearly and thus the impact from, for example, active social media use to emotional exhaustion one year later must be somewhat speculative due to the long distance between measurement points.

The approach in Study III was slightly different compared to Studies I and II, as participants' open responses related to socio-digital engagement were analyzed and the gap between measurement points ranged from a few hours to a day. In their morning diaries, participants used open answers to report what they did 30 minutes before going to bed the previous night. We did not know before the data collection what kind of activities they would report. Sending messages to friends (defined as active social media use) and scrolling through social media (defined as passive social media use) were, however, the most frequent activities. This also

supported the assumptions made in Studies I and II, i.e., if adolescents report frequent friendship-driven socio-digital engagement in general, they probably also engage in these activities during the evenings before bedtime.

Study III included data from the moments when the activities occurred in real life settings with repeated measures, which recall biased self-reports. In terms of sleep measures, only self-reported measures of sleep were examined in Studies I and II, which surely increases the possibility of biased measures. Therefore, in Study III, bedtimes were measured objectively with activity bracelets to avoid biased self-reports. This type of study longitudinal research design allowed me to analyze the data using multilevel approach and to separate associations that occur on the day level from associations that occur between students. In addition, this type of study design enabled investigating whether psychosocial factors moderate the daily associations. That said, these analytical approaches allowed modeling the complex theoretical assumptions suggested in the literature (Valkenburg & Peter, 2013; Steele et al., 2020).

Study IV was a narrative review, which emphasized key studies, systematic reviews, and meta-analyses that investigated the associations between socio-digital engagement and academic functioning (academic well-being, performance, and engagement). Existing literature related to the topic was reflected through the lens of the DC-DDR model. To my knowledge, this was the first literature review focused on academic well-being and engagement instead of focusing solely on academic performance. In addition, it considered various contextual and developmental factors. However, Study IV was not a systematic literature review, which indeed would have increased its reliability and reproducibility along with transparency related to the choices made during the writing process.

Investigating socio-digital engagement is difficult because platforms develop at a rapid pace and new platforms are introduced to users frequently. This is a challenge to researchers investigating socio-digital engagement because adolescents typically rapidly adopt novel digital platforms (Vogels et al., 2022). This was considered in the original studies by using measures and items that were not related to a specific platform, but rather the practices and features that occur in many online settings were measured. For example, items "I follow the profiles, pictures, and activities of my friends" or "I watch videos and photos online" are not dependent on a specific platform but describe overall motives and practices. This was especially important in Study II, a longitudinal study over six years, during which it was key to use the same measure each year. Future research could also implement digital markers of adolescent socio-digital engagement to better understand how and why adolescents engage online (see for example Aalbers et al., 2023).

Measures related to school burnout and schoolwork engagement in this thesis were established and validated beforehand with various samples, especially in

Finland. Study II and Study III indicated contradictory results related to the associations between socio-digital engagement and academic well-being in late adolescence. Emotional exhaustion (in Study II) was described as long-term feelings of tiredness, sleep problems due to schoolwork, and ruminating about school-related issues (Salmela-Aro et al., 2009b). Study III, however, focused on momentary feelings of tiredness, stress, and anxiety, which may reflect different domains of well-being even though they appear during the school day. Study II focused on long-term effects by investigating emotional exhaustion and Study III focused on short-term effects by investigating momentary feelings during school days. That said, the School Burnout Inventory and the Schoolwork Engagement Inventory measure different aspects of academic well-being than did the momentary measures during school days. The use of momentary measures in this study had limitations, as it was primarily exploratory and relied on single-item assessments. However, a notable strength was that these measures were collected in real-life contexts and considered the timing of assessing academic well-being. Similarly, in Study II, the Socio-Digital Participation Inventory gauged the frequency of friendship-driven socio-digital engagement, while in Study III, the focus was solely on whether this type of activity took place in the evening or not. Thus, the strength of Study III was that it also accounted for socio-digital engagement. The contrary findings indicate that the operationalization of socio-digital engagement may bring out different effects.

This thesis underlined the theoretical approach presented by Valkenburg & Peter (2013), which states that individuals have different susceptibilities, and several factors moderate the media effects on well-being. In addition, this thesis focused on the technology effects perspective (Meier & Reinecke, 2021), where using technology is assumed to be the causal factor influencing well-being. Study II, however, also investigated reciprocal associations, but in one-year time lags, which reduces the possibility of drawing strong causal interpretations. In future research, it would be important to emphasize more such an approach, where pre-existing challenges in academic well-being are assumed to influence socio-digital engagement, also referred to as the technology selection perspective (Meier & Reinecke, 2021). Adolescents that have challenges in offline settings may use technology for coping. This would indicate that technology use is more a symptom of ill-being rather than the causal factor of well-being. In addition, these processes may occur simultaneously as a vicious cycle. One limitation in this thesis was that it did not control for various mental health conditions (for example, depressive symptoms). This issue needs to be considered in future studies that focus on socio-digital engagement, sleep, and academic well-being. To examine these complex processes, researchers need sophisticated data designs. Datasets with repeated measures allow researchers to investigate complex multilevel processes. These can be analyzed, for example, with dynamical structural equation analyses (DSEM; Asparouhov et al., 2018).

In terms of statistical analyses, sophisticated data designs require models that consider the potential differences between group-level associations and person-level associations, and that socio-digital engagement has differing effects on well-being in different subgroups (see for example Johannes et al., 2021a, preprint; Molenaar & Campbell, 2009). After all, the effects of socio-digital engagement are within-person effects (Valkenburg & Peter, 2013; Valkenburg et al., 2016). In other words, this thesis explored, for example, whether adolescents using social media more differ from those who use it less (between level) and whether using social media more than average is related to changes in that person's well-being or sleep (within person). In Studies II and III, the within- and between-level associations were separated statistically, which was definitely a strength. In addition to these two levels of variance, the associations were also seen to be time-varying (Molenaar & Campbell, 2009).

This thesis investigated the associations between socio-digital engagement, sleep, and academic well-being by separating the variance into within and between levels and additionally included moderators for examining the possible subgroups with divergent effects. In Study I, gender was seen as the moderator despite the statistical analyses not specifically testing for moderation. However, Study I did show that gender in early adolescence may moderate the effects, as differences in the results were observed between the two selected genders, i.e., girls and boys. It is very likely that the question does not deal with gender itself but is more concerned with the ways in which adolescents engage socio-digitally. Study II supported this, as the interpretation of the results did not change after controlling for gender. Study III also included moderators in the models. The cross-level interactions indicated that the associations differ between individuals in relation to how much social pressure and availability stress participants' experience. These differential effects between individuals could, in future studies, be examined differently using person-oriented analyses (for example, profile analyses) or this could be modeled using multigroup structural equation models. Instead of separating girls and boys, the separation should be done, for example, based on the motive for socio-digital engagement, socio-digital habits (i.e., multitasking preference), how individuals perceive social-digital engagement (psychosocial factors), or based on pre-existing mental health conditions.

Thus, the role of socio-digital engagement on sleep and academic well-being among adolescents should be investigated longitudinally in future studies, with varying time scales between the measurement points, and individual differences should be emphasized. It is plausible that some adolescents are not at risk, and socio-digital engagement is not detrimental to their sleep or academic well-being, merely increasing their social resources in daily life. For others, however, socio-digital engagement can further increase daily demands and thus challenge individual well-being. Collecting both long- and short-term repeated measurements

from individuals allows researchers to model the effects of socio-digital engagement on sleep and well-being processes within individuals across various time scales. Objective measures of well-being (i.e., heart rate variability to measure stress reactions) or digital markers of individual socio-digital engagement could further help researchers understand how and why adolescents are engaging online and what kind of benefits or disadvantages this has on their sleep and well-being.

5.6 Pedagogical considerations

The national curricula in Finland emphasizes broad-based competencies. These competencies do not relate only to a specific subject but are competencies that aim to equip students for future life (Lonka, 2018). These competencies include, for example digital skills, life management skills, and socio-emotional skills. In addition, taking care of personal well-being is one theme linked to many topics in the curricula. Some interventions are showing promising results (see for example Wineburg et al., 2022), where teaching digital skills can improve students' skills; however, digital skills are often seen as more technical or informational in nature instead of being life skills. In addition to schools' influence regarding these skills, adolescents adopt boundaries and attitudes towards socio-digital engagement from their parents (Lauricella & Cingel, 2020; van den Eijnden et al., 2021). Therefore, aiding parents in how to support their childrens' digital engagement would be important.

This thesis investigated socio-digital engagement and focused especially on social media use that is often a friendship-driven activity. In addition, it focused on the social demands that adolescents experience related to the norms where individuals should be and want to be constantly available to others. To tackle these demands, adolescents need socio-emotional and self-regulative skills that can be seen as personal digital psychosocial resources. These skills and competencies partly overlap with the skills required in offline settings; however, some skills are more important in online settings (Reich, 2017). These skills can be taught and learnt, and children and adolescents need help in developing them.

That said, self-regulative and socio-emotional skills are highly important to adolescents to cope with all stressors and demands that arise from socio-digital platforms or from peers. These skills can work as a buffer against the negative effects of socio-digital engagement. There are strategies on how to avoid social media distractions (Brevers & Turel, 2019), for example by ensuring that the phone is not causing constant disturbance, which can be achieved by turning it on silent or on airplane mode and sometimes by taking longer breaks from social media. Related to sleep, adolescents should be taught to avoid the bright light transmitted by devices close to bedtime (i.e., using blue light filters) and to avoid

technology use that might delay bedtime or interfere with sleep quality, for example playing video games (Eggermont & Van den Bulck, 2006). Some digital activities, such as good night wishes to friends, on the other hand, can be beneficial for adolescent sleep. However, adolescents differ in self-control (Casey & Caudle, 2013; Willems et al., 2019), which means that these strategies may be easier for others. In other words, parents and professionals should consider the age and individual characteristics of adolescents because individuals may need different kinds of support in developing these self-regulative skills.

Adolescents are active agents in their own practices of socio-digital engagement, which means that they not only passively consume online content but also shape and create new practices and content online. However, they concurrently face social, emotional, and physiological developmental challenges, which together with demands from the digital world can be overwhelming. It is also important to acknowledge that adolescents may not seek help when they face difficulties in online environments (Livingstone et al., 2022), thus the role of parents and professonals is highly important. It would be important to routinely screen for signs of problematic socio-digital engagement that might impair adolescents' daily abilities to engage in daily roles and routines (American Psychological Associations). Instead of only reducing the time spent online, professionals and parents should support adolescents in developing skills that promote well-being in the digital era. Overall, self-regulation plays an important role in shaping adolescents' digital behaviors (Reinecke et al., 2022), which in turn can have an impact on their well-being outcomes. Related to parenting, a supportive and open communicative approach to adolescents' socio-digital engagement may enhance adolescent well-being more than a controlling and restrictive approach (see for example Barry e& Kim, 2023). Considering the developmental phase is important, because controlling or forbidding access to peer networks may increase loneliness and decrease well-being, especially during adolescence when peer acceptance is highly valued (Barry e& Kim, 2023).

Multitasking and distractions are associated with adolescent socio-digital practices, which can be harmful for cognitive ergonomics (Firth et al., 2019) and contribute to increased daily demands. However, it is important to note that not all adolescents develop addictive smartphone use habits, and there is considerable variation in smartphone use habits among adolescents (see for example Lahti et al., 2018 or Meier et al., 2022, preprint). Some adolescents exhibit greater resilience and can engage in digital activities without significant challenges. Additionally, social inequalities exist among adolescents. Some grow up in environments where parents and social influences facilitate the fruitful use of digital devices, while others grow up in contexts with fewer resources (Dahl et al., 2018). In this frame, educators play a pivotal role in ensuring that all adolescents acquire the necessary skills to effectively balance the diverse demands and resources associated with socio-digital practices (Hur & Gupta, 2013; Lonka, 2018).

While this thesis did not specifically focus on the content that adolescents engage with online, exploring this aspect would be important in future research. This also relates to teaching media literacy skills, which are important skills now and in the future, given the vast amount of content available in online environments. Most often individuals prefer to engage with content that is only moderately discrepant from personal age-related comprehension experiences (Valkenburg & Peter, 2013). Professionals and parents should not solely rely on adolescents' media literacy skills, and it remains important to be aware of the content that adolescents are engaging with online. However, monitoring such content can be challenging. To address this, many social media platforms have age restrictions in place, typically demanding that users be 13 years of age or older. It is crucial for parents to consider these restrictions and guide their children accordingly.

Taking a restrictive approarch by outright banning digital devices or harshly judging adolescents for their intensive phone use may not be the most effective way to address the issue (Hur & Gupta, 2013; van den Eijnden et al., 2021). Instead, we should guide adolescents on how and when various dimensions of the digital world can help us achieve our personal goals both within and outside of school. Given the prevalence of digital distractions, it is essential to educate adolescents about effectively managing and minimizing these distractions, including identifying situations where digital distractions are prohibited. For example, when an individual needs to focus on reading or doing assignments at school, it is best to keep away from the phone. On the other hand, there are situations also during school days when searching for information, checking messages from friends, or watching a video is not distracting from learning. Indeed, when adolescents possess the knowledge and skills to utilize digital media as a resource in a productive manner, it can contribute to their development and preparation for adulthood. Understanding how to effectively utilize digital media can empower adolescents, enabling them to develop into fully functioning adults in an increasingly digital world (Hur & Gupta, 2013).

To sum up, digital platforms play a large role now and in the future, both within and outside of school. Digitalization in schools often refers to digital solutions that help with learning tasks (such as learning games). In Finland, the national curricula place significant emphasis on the integration of digital devices and solutions into schoolwork, aiming to enable students to learn how to utilize them in a beneficial manner. However, much less focus is set on the skills that adolescents require for navigating in the digital world and skills that can protect from the negative consequences of digital engagement. Finnish education has a long history in teaching healthy lifestyles, and digital skills are skills that really matter when finding a healthy balance in life in the 2020s. Overall, promoting self-regulation skills among adolescents requires a combination of teaching, modeling, and practice. By offering opportunities for adolescents to develop and exercise their self-regulation skills pertaining to socio-digital engagement, we can support their ability to

effectively manage and navigate digital opportunities, which further supports adolescents' academic success, relationships, and overall well-being.

5.7 Concluding remarks

The pervasive presence of digital platforms, solutions, and devices in our lives has raised significant concerns about the impact of screen time on individuals, especially adolescents. However, it is evident that not all screentime is created equal, as adolescents engage in the digital world in diverse ways and for diverse reasons. That said, adolescents differ also in how they are affected by their socio-digital engagement. This dissertation highlights the importance of investigating adolescent perceptions of socio-digital engagement and individual differencesr to gain a comprehensive understanding of its influence on adolescents' daily lives.

Moreover, it is crucial to acknowledge the developmental and educational factors that shape adolescents' experiences with digital media. Friendship-driven socio-digital engagement can have positive effects in late adolescence, as individuals in this developmental stage often have more developed skills to regulate their own behavior and habits compared to younger adolescents. Additionally, having peer networks both online and offline allows for meaningful interactions and social support that contribute to their overall well-being. When utilized appropriately, socio-digital engagement can be beneficial for adolescent sleep and academic well-being. However, adolescents across all developmental stages require support in developing self-regulatory and socio-emotional skills in relation to socio-digital engagement. By cultivating these essential skills, adolescents can develop a balance between the demands related to socio-digital engagement and personal resources. These self-regulative and socio-emotional skills can serve as personal psychosocial resources for tackling the demands. Indeed, teaching and learning these skills is crucial and necessitates support from parents and professionals. Recognizing that the balance between socio-digital engagement and other aspects of life differs for each individual is essential. Different contexts and situations may require different approaches to achieving a healthy and personalized balance.

Rather than banning devices, guidance should emphasize teaching adolescents how to utilize the digital world effectively and discern when and how to engage with it. This approach empowers adolescents to develop responsible and mindful digital habits while maximizing the benefits and minimizing the potential drawbacks of digital technology. Recognizing that phones can be both distractions and tools for learning, schools must consider the context in which they are utilized. By incorporating digital devices into schoolwork, educators can harness their potential for enhancing engagement, collaboration, and information access while teaching students how to navigate digital platforms responsibly and in a beneficial way.

To gain a deeper understanding of the influence of socio-digital engagement on sleep and well-being, researchers should shift their focus from solely measuring screentime to exploring the perceptions and feelings that such engagement

enhances. Examining how socio-digital engagement enhances individual experiences and feelings can provide valuable insights into the complex relationship between digital technology use and well-being outcomes. This thesis, therefore, focused on both the behavioral and the psychosocial components of socio-digital engagement by investigating the frequency of use, timing of usage, and perceived demands related to socio-digital engagement. In future studies, researchers should move forward by also investigaing how various pre-existing challenges (i.e., symptoms of burnout) may affect how and why adolescents spend time online during their leisure time. Future research could delve deeper into the effects of prolonged and extensive socio-digital engagement, including its impact on cognitive, social, and emotional development.

To sum up, a comprehensive understanding of socio-digital engagement among adolescents necessitates an exploration of individual perceptions, developmental factors, self-regulatory and socio-emotional skills, and the dynamic interplay between demands and resources. By focusing on these aspects, researchers, educators, and parents can promote a healthy and balanced relationship between adolescents and their socio-digital engagement, fostering their overall well-being and equipping them with the necessary skills for the digital age.

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