Computers & Education 194 (2023) 104705

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Mobile media education as a tool to reduce problematic smartphone use: Results of a randomised impact evaluation

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ARTICLE INFO

Keywords:
Problematic smartphone use
Digital skills
Digital well-being
High school
Media education
Cluster randomised controlled trial
Teacher training
Youth and digital media

ABSTRACT

In recent years a public debate has been growing around mobile media and young people, as research has found adverse relationships between the intensive use of smartphones and well-being in this age group. However, there is still a lack of structured interventions targeting teachers and schools on the issue. This paper shows the results of a pre-registered cluster randomised controlled trial evaluating the impact of a media education intervention focusing on screen time management and the conscious use of mobile devices. The impact of a teacher training course is assessed on their 10th grade students (789 treated, 2572 controls), looking at their smartphone use, digital skills, and subjective well-being. Post-intervention differences, controlling for baseline measures at wave 1, show a moderate but significant decrease in smartphone pervasiveness and problematic use among treated students, with girls displaying greater beneficial effects than boys on withdrawal symptoms. Girls also show an increase in subjective well-being. No effect is found on the level of digital skills measured with an ad-hoc test. These results highlight that media education interventions focused on screen time management and content-related digital skills can be effectively incorporated into daily teaching and are relevant for students' well-being. The paper also offers practical indications to develop effective media education interventions in a constant connectivity environment.

1. Introduction

The relationship between adolescents and mobile media is often at the core of public debate. In recent years, due in particular to the spread of smartphones, screen time has increased for every age range, but especially for children and adolescents (Ofcom, 2020). Thanks to their smartphones, many teenagers are online on a near-constant basis (Pew Research Center, 2018), and further increases in online time were reported during the Covid-19 pandemic (Nagata et al., 2022). As regards the Italian context, in which the present study is located, a recent international survey reports that 84% of children aged between 9 and 17 years old access the internet daily from their smartphone, in line with their European counterparts; on the other hand, Italian children rely on a lower level of digital skills compared with the EU average (Smahel et al., 2020).

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https://doi.org/10.1016/j.compedu.2022.104705
Received 15 November 2021; Received in revised form 6 December 2022; Accepted 8 December 2022
Available online 9 December 2022

In the empirical literature, apart from a small minority of pathologically "addicted" young users (Kim et al., 2014; Kwon et al., 2013), less severe but more widespread problematic implications of mobile media usage on youth have emerged. Research has found negative correlations between smartphone use and outcomes such as lack of concentration (Kim, Kim, et al., 2019; Kushlev et al., 2016), procrastination (Rozgonjuk et al., 2018), poorer sleep quality (Christensen et al., 2016; Hughes & Burke, 2018), lower satisfaction with body perception (Schmuck et al., 2019), lower quality of offline social experiences (Bae, 2015; Kim et al., 2018; Mahapatra, 2019), more offline family conflicts (Kim, Min, et al., 2019) and ultimately diminished school performance (Gerosa et al., 2022; Gui & Gerosa, 2021; Liu et al., 2020; Amez & Baert, 2020; Samaha & Hawi, 2016; Przepiorka et al., 2021). A number of studies have also found a negative correlation between intensive smartphone use and life satisfaction (e.g. Rotondi et al., 2017; Twenge et al., 2020; Vahedi & Saiphoo, 2018), although its causal interpretation is strongly debated (Orben & Przybylski, 2020). It is to be noted that in this field of research, sharp gender differences emerge, with girls spending more time on smartphones and being more at risk of problematic use (Busch & McCarthy, 2021; Camerini et al., 2021; Demirci et al., 2015; Lin & Chiang, 2017).

While emphasising the negative effects that the use of digital devices has on young users, it must also be highlighted that online activities can also be beneficial for their well-being. Recent literature recommends acknowledgement of the benefits of connectivity when developing interventions to tackle the discomforts that it brings (Roffarello & De Russis, 2019; Vanden Abeele, 2021). Digital media are described as enablers of people's independence and fulfilment, as well as providers of pleasure and enjoyment (Vanden Abeele et al., 2018); in other words, facilitators of hedonic and eudaimonic experiences, which are associated with individuals' well-being (Huta, 2016). Hence, a conscious use of digital media should be aimed at enabling media users to profit from their relationship with technology by being aware of and capable of managing the threats of online life. This has been theoretically summarised in the concept of "digital well-being" (Gui et al., 2017; Büchi, 2020), which can be defined as "a state where subjective well-being is maintained in an environment characterised by digital communication overabundance" ((Gui et al., 166, 2017)).

Attention has been drawn to a lack of rigorously evaluated interventions on "digital well-being" targeting teachers and schools (Eurydice, 2019; Themelis & Sime, 2020). Families are also beginning to request that education should address the risks of the unconscious use of digital media (Throuvala et al., 2021). To help fill this gap, in this paper we introduce a newly developed one-year light training intervention targeting high school teachers, and their 10th grade students, and evaluate its effects in increasing digital awareness, reducing problematic media use, and, ultimately, enhancing students' well-being.

1.1. Mobile media use and education

The challenges posed to young users by mobile media are a mix of new and old issues. On the one hand, young people experience difficulties in controlling their use of mobile media and sometimes suffer from related impaired daily functioning (e.g., Camerini et al., 2021), which is referred to in the literature as 'problematic smartphone use' (see Busch & McCarthy, 2021). As a result, self-control and time and attention management become key factors in "digital well-being" (Fasoli, 2021; Hefner et al., 2017). On the other hand, the use of mobile devices can become problematic not just because of the quantity and pervasiveness of their use, but also because of a lack of awareness and strategic thinking in their use. Indeed, 'content-related digital skills' (Van Deursen & Van Dijk, 2014) - the more "traditional" part of digital literacy - are even more key in an environment of permanent connectivity (Buckingham, 2019; Chayko, 2020). In this field, there is already much theorising about digital skills models to be developed in schools (Iordache et al., 2017). General frameworks of digital literacy have also been developed by transnational institutions such as UNESCO and the European Union (UNESCO, 2011; Vuorikari et al., 2016; Vuorikari et al., 2022).

Screen time management and content-related skills are, however, interrelated. For example, compulsive smartphone use has been found to be associated with a passive use of social networking sites (Karsay et al., 2019; Panek et al., 2018), which in turn is associated with problematic social comparison (see Liu et al., 2019). Indeed, communication overabundance is associated with limitations in cognitive resources for critical thinking (Elhai et al., 2019; Gui et al., 2021).

There is agreement that schools should target both of these issues in order to enhance students' well-being in permanently online environments (Eurydice, 2019; Kwon, 2011; Yu & Shek, 2013). However, educational systems appear unprepared to respond effectively to such a challenge. So far, schools have mostly dealt (and struggled) with new media as teaching tools, introducing educational technologies in classrooms to foster knowledge acquisition within the disciplines (Selwyn, 2016). Instead, when it comes to education about a conscious use of digital media, schools largely lack a structured approach (Buckingham, 2013, 2019), and most students acquire their media literacy autonomously (Mesquita-Romero et al., 2022). This happens despite the fact that more and more parents are calling on schools to take on the task of providing students with education about the risks of unconscious use of digital media (Throuvala et al., 2021). Research can provide a valuable contribution by developing indications about how to design and implement interventions of this kind, and assess whether they are effective in reducing problematic media use and enhancing students' digital skills, and ultimately their well-being.

Although media education projects on mobile screen time management are increasingly tending to emerge (Chung et al., 2019; Themelis & Sime, 2020), so far very few have been rigorously evaluated. Throuvala et al. (2020) carried out a 10-day online randomised controlled trial on 143 UK university students. The intervention used smartphone monitoring apps, mindfulness exercises and mood tracking. The results show a significant reduction in smartphone distraction, stress and anxiety. Bonnaire et al. (2019) performed a media education intervention on French adolescents targeting internet use and gaming disorder, with a significant reduction of time online.

Very few studies have rigorously evaluated media education interventions on "content-related digital skills'' (Van Deursen & Van Dijk, 2014). Gordon et al. (2021) performed a randomised controlled trial in Australia to evaluate an intervention addressing topics such as eating disorders, body dissatisfaction and the relative psychological effects. The long-term findings emphasise that the

intervention was effective, but had a different appeal for girls and boys. Specifically, social media literacy seems to be more effective in preventing eating disorders and correlates among girls than among boys, an issue that manifests itself with the same gender specificity. Finally, Mesquita-Romero et al. (2022) performed a media education intervention among students of a high school in Colombia. The programme was delivered by teachers during school hours. The results showed that overall the intervention had a significant effect on the students' media competence and performance. Together, these findings provide support for school based digital media literacy actions.

However, the encouraging evidence presented by these studies does not constitute a sufficient basis of information to develop structured, comprehensive and sustainable routes of media education in the mobile era. First, extant evaluations focus on specific aspects of digital media education, while the conscious and responsible use of mobile media, thanks also to its multifunctional nature, depends on a broader set of strictly interdependent skills, and in particular on a mix of screen time management and content-related skills. Second, existing studies on media education interventions mostly make use of external experts (Busch et al., 2013; de Leeuw et al., 2010; Turel et al., 2015), whereas the involvement of teachers is recommended in order to ensure didactic continuity and achieve a significant impact in terms of behavioural and cognitive change in school-based media educational projects (Gordon et al., 2021; Vondráčková & Gabrhelik, 2016; Walther et al., 2014). Therefore, we still lack experimental evidence proving that teachers themselves can be trained to adequately and sustainably carry out mobile media education within their daily activities in class. Third, we do not know to what extent these interventions impact students' subjective well-being. As far as we know, only Gordon et al. (2021) have carried out an RCT measuring well-being as an outcome of a media education intervention, even though it was limited to issues related to body image and dietary concerns. Therefore, knowledge on how to construct interventions that lay the foundation for full "digital well-being" is fundamental.

1.2. The Digital Well-Being - Schools programme

This study aims to empirically fill the aforementioned research gaps in order to offer schools practical indications about how to effectively implement media education interventions in the context of permanent connectivity resulting from mobile media. To do so, we introduced a newly developed media education programme targeting high school teachers and their 10th grade students and evaluated it by means of a cluster randomised trial. Digital Well-Being - Schools (in Italian *Benessere Digitale - Scuole* and hereinafter DWB-S) consists of a light training intervention to help teachers plan and implement media education activities for the promotion of conscious, strategic, and responsible use of mobile media including outside school and, ultimately, to enhance students' well-being. The training package covers a broader set of interdependent digital skills than previous interventions, combining both dimensions of well-being in mobile environments outlined above: time and attention management in daily life and online content management. Moreover, it was developed in collaboration with schools with the explicit intent of offering an alternative to traditional approaches based on spot interventions led by external trainers, by providing teachers with the "toolbox" needed to discuss the critical issues of digital technology autonomously in their classrooms.

A group of experts in media education and adolescents' well-being, school principals and experienced teachers was assembled in the form of a steering committee, in order to draw up a detailed protocol for a comprehensive and easily implementable media education intervention.[1] The training was designed to be administered to teachers in a blended environment, and was divided into four modules: *Time and Attention Management, Communication and Collaboration, Information Evaluation* and *Digital Content Production*.

Each module was structured in a first stage of online preparatory work followed by in-person training with media educators focusing on basic concepts and lesson planning suggestions. Teachers were provided with the theoretical basis and actual lesson plans to deliver a 3-h "media awareness experience" in their classroom. At the end of each experience, they were invited to cooperate with students in defining a *good digital habit* emerging from that specific experience, to be consolidated inside and outside of school (with family, friends, etc.) for the rest of the year. The *habits* were devised by the research team to extend and reinforce the impact of the media experiences well beyond the 12-h classroom project. For this reason, teachers of the involved classes were invited to refer to them daily during their class time throughout the year.

In the first module, which focused on time and attention management, students were invited to download a monitoring app to keep track of their smartphone-related activities. Research shows that monitoring apps can foster digital self-awareness, although their use should be accompanied by self-imposed goals to modify habits (Rooksby et al., 2016; Zimmermann, 2020). For this reason, one week later, students were guided by teachers in developing an "Attention Management Plan" based on this activity report, to identify forms of self-regulation in media use and set personal time management goals. Based on the negative relationship emerging between parents' misuse of mobile phones and children's well-being (Pancani et al., 2021; Xie & Xie, 2020), teachers asked students to share these goals with their families in order to rethink their habits during time spent together.

The other three modules covered the most relevant domains of digital skills drawn up by the European Digital Competence Framework for Citizens (DigComp 2.1): peer-communication, information management, and digital content production. Module 2 addressed the management of online relationships and conflicts, examining real-life examples from mobile instant messaging applications and social media. The experience involved the collective creation of a class group netiquette. Module 3 focused on searching for information using specific techniques, checking the validity of sources, and knowledge management. An online search on a specific topic was then proposed to the class, asking students to rank the results based on their reliability and to give reasons for their decisions.

[1] For further details about the composition of the steering committee, see https://www.digitalwellbeing.eu/digital-wellbeing-schools/

The collated criteria were finally included in general guidelines for the class. Module 4 concerned responsible online content production, publication, promotion, and sharing. Students were divided in groups and asked to create and publish a simple product (a 'meme') with their own devices. In doing so, they were asked to follow a checklist for designing digital products responsibly and consciously. Referring to the checklist every time something digital was produced from then on represented the final *good habit* of the module.[2] The collective outcome of each module was finally summarised in a poster that was permanently hung in the classroom.

The four modules were developed to cover both the area of time and attention management (module 1) and online content management (module 2, 3 and 4). The topic of time and attention management has been conceived as an enabling condition for acquisition of the more traditional digital literacy skills. For this reason, module 1 was positioned at the beginning, so that the *good habit* developed through it could follow the students throughout the year and accompany, as a background, the activities of the other three.

Based on the public utility objectives of the project, all the materials of the training are now available free of charge for Italian teachers on a dedicated platform.[3]

1.3. Hypotheses

Building on the general purposes of evaluating the feasibility of the DWB-S programme and its effectiveness in fostering students' well-being in a digitally saturated environment, we formulate the following hypotheses:

H1. The DWB-S intervention will be successfully implemented in treated classes. We expect to find evidence of an extensive exposure of treated students to media education activities over the year, with consequent growth in the perceived support from teachers in the use of digital media.

H2. Students' exposure to the intervention will effectively reduce problematic smartphone use. We expect that module 1, in particular, will increase students' awareness of how much time they spend online, and of how much the activities carried out digitally are consistent with their own daily life goals. However, we also expect that the other modules (2, 3 and 4) will help change students' approach to online activities by shifting attention from passive fruition to reasoned activities consistent with one's objectives, thus exerting additional pressure to reduce the compulsive use of mobile media.

H3. The intervention will increase content-related digital skills and capital-enhancing digital media use. We expect that modules 2, 3 and 4, in particular, will provide students with additional skills to becoming informed, relating online and producing quality content. We also expect that module 1 will contribute to this increase in digital skills by reducing time displacement in favour of a more capital-enhancing daily use of digital media.

H4. The DWB-S intervention will positively affect students' subjective well-being, based on the centrality of online activities in youth's daily life. A reduction in smartphone disturbances at relevant times of the day, as well as the gratification derived from satisfying one's needs through the conscious and effective use of new media, could indeed favour a growth in subjective well-being.

H5. In light of the gender gap detected by extant research (Busch & McCarthy, 2021; Demirci et al., 2015; Lin & Chiang, 2017), we expect to find girls showing higher levels of screen time and problematic smartphone use compared with their male counterparts before getting involved in DWB-S. Moreover, based on the mechanisms outlined above, we expect that our intervention can especially help them to compensate their disadvantage, thus contributing to reducing the gender gap in smartphone problematic use and, consequently, to more consistent growth in girls' general well-being.

2. Data and methods: the randomised controlled trial

The impact of the DWB-S intervention was assessed at the student level, using a cluster trial pre-registered in the Social Science Registry.[4] We look at the variations in perceived teacher support, smartphone time management skills and problematic use, online information and relationship management skills, capital-enhancing digital media use and subjective well-being. Randomised trials are rapidly gaining attention in the evaluation of education interventions ((Abbiati et al., 2022)), as they are a powerful tool for developing rigorous causal inference.

The following subsections present the sampling protocol of the study, the randomisation procedure, the intervention delivery, data collection and analytical approach we used to answer our research questions, in accordance with the CONSORT trial diagram shown in Fig. 1.

2.1. Sampling

An invitation to take part in the DWB-S project was sent to all 42 high schools in three administrative districts in the North of Italy. A multiple-stage enrolment procedure was adopted to ensure that school principals and teachers were all properly informed about the

[2] For more details on the module contents, see https://www.digitalwellbeing.eu/digital-wellbeing-schools/
[3] www.benesseredigitalescuole.it
[4] https://www.socialscienceregistry.org/trials/2990

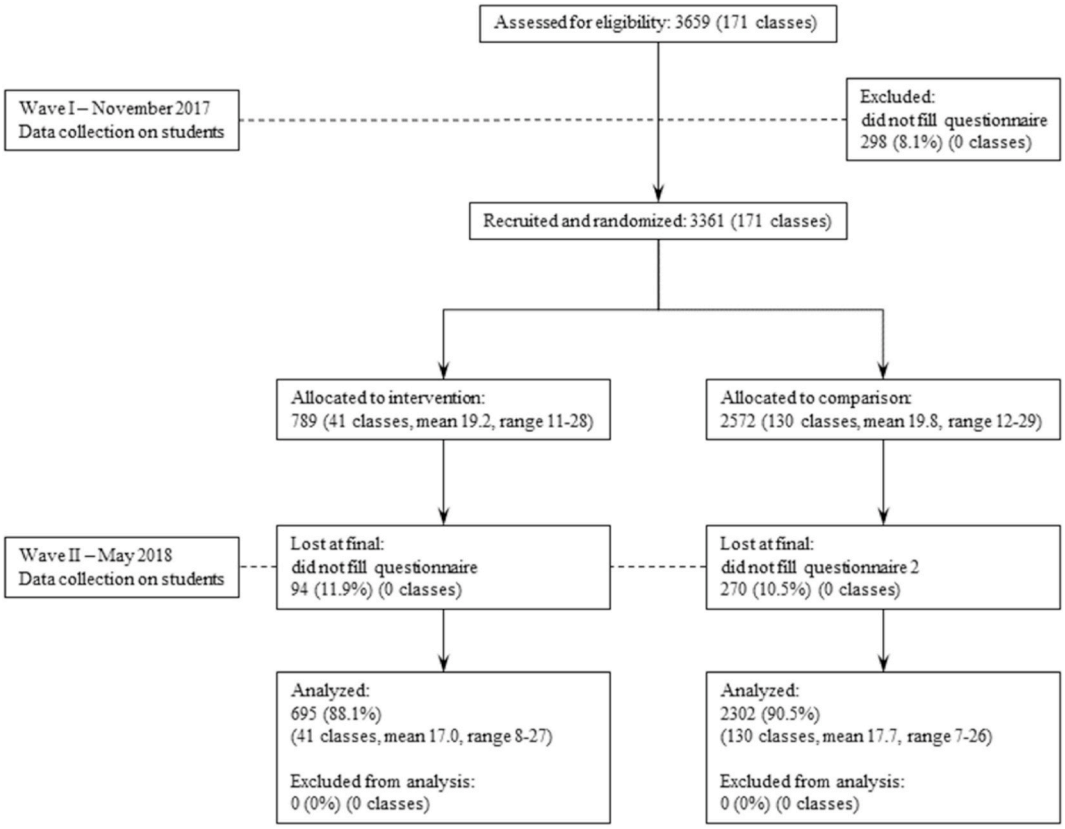

Fig. 1. Flow diagram of the cluster randomised trial (number of students and classes).

project structure, contents, aims, and requirements, to avoid them subsequently dropping out during the experiment. The DWB-S project planned for the allocation of about 80 teachers (2 teachers per class) to the intervention, for a total coverage of about 41 classes and around 820 students. Using PowerUp power calculation software taking into account the sample design and clustering, we estimated that the total number of comparison units to be involved in the trial was 130 (around 2600 students), in order to detect effects on primary outcomes of 0.106 standard deviations, an effect in line with if not greater than the usual mean effect size for educational interventions (Demack et al., 2021; Kraft, 2020). We then recruited the first 18 schools that signed our cooperation agreement, respecting the distribution of the different school types located in the districts being studied, for a total of 171 10th grade classes and 3659 enrolled students. A more detailed description of the sampling procedures is offered at the pre-trial registration page.[4]).

2.2. Randomisation

In October 2017, all the 10th grade classes of the 18 high schools were randomly allocated to an intervention group (41 classes) or to a comparison group (130 classes). This procedure was conducted at class level, using a random allocation sequence based on sequentially numbered containers. The Italian upper secondary school system has a broad range of Tracks Of Study (TOS), from the academic to the vocational. Some of the recruited schools offered only one TOS at the time of the intervention, while others had two or more. In the overall sample, the classes were organised into five main TOS: lyceum (scientific area), lyceum (other areas), technical school (economic area), technical school (technological area) and vocational school. Our constraints were: a) guaranteeing the direct involvement of all the schools in the first year of the intervention; and b) ensuring an equal distribution of the 10th grade classes from each of the above-mentioned TOS between treated and control groups. We opted for a randomisation approach based on blocks of classes defined by TOS. A total of 31 intra-school blocks made of classes with the same TOS within each school were identified. In addition, other two inter-school blocks were created to cover those TOS that had only one class within a specific school. Randomisation was carried out within each of the 33 blocks, randomly assigning one class to the treatment if the block contained six or fewer classes, and assigning two classes to the treatment if the block was made up of seven or more classes.

As displayed in Table 1, our randomisation process successfully balanced the treatment and control groups across a wide set of socio-demographic characteristics measured at both the individual and class level. Similar results emerged also in the cross-group distribution of the selected outcomes collected before the intervention (see the Supplementary material), proving that - at the baseline – the treatment and control groups were equivalent.

2.3. Implementation of the intervention

The teachers of each class assigned to the treatment collegially selected two from among them to take part in the training initiative during its first roll-out (AY 2017–2018), while those in the comparison group were assigned to a waiting list and asked to attend the training the following school year (AY 2018–2019).[5] To encourage greater exposure of treated students to the training content and reduce the likelihood of teachers working in more than one 10th grade class being trained (i.e. to reduce the risk of contamination), it was requested that the sum of the total hours per week spent by the selected teachers on the individual class assigned to the treatment would be equal to or greater than seven.

The four training modules of the DWB-S intervention were provided to all the selected teachers of the treated classes between December 2017 and April 2018, at variable time intervals depending on the school calendar. Teachers' compliance with each of the four training modules was monitored first by looking at their presence at the meetings. They were also invited to fill in an online questionnaire after each activity was implemented in class, summarising the work they had carried out and the material they had produced with their students. By cross-referencing the information on attendance with that collected from the questionnaires, we estimated the number of teachers that successfully implemented the entire programme: 89% of teachers had carried out all the activities required for each module. However, considering that teachers worked in pairs or took turns to organise and implement the workshops with the students, we can conclude that about 98% of students were exposed to all the project activities. Only one of the classes assigned to the treatment did not complete the entire training programme, although it successfully completed the first two training modules. At the same time, none of the control group classes were treated, so we ended up with a situation close to full compliance.

To deal with the risk of contamination, we investigated the issue by asking enrolled schools for information about how many of the trained teachers would teach in both treated and control classes. Overall, we found that 43% of them would also be working in one or more control classes, thus generating the risk of type II error. This is the reason behind our request to train teachers, to avoid them either sharing any of the course content with other colleagues or replicating the DWB-S media education activities in other classes outside of the treatment for the entire school year. Moreover, at the end of the intervention, we looked at variations in the distribution of perceived teacher support (see the outcomes section) to evaluate students' potential exposure to the course content. We detected a modest increase for control group students over the year ($w1 = 40.1[38.9; 41.3]$; $w2 = 41.5[40.2; 42.8]$; $p = 0.037$) that, however, cannot be causally attributed to the intervention. Indeed, this increase is plausibly due to several factors, such as the longer exposure to teachers in wave 2 compared with wave 1. In the light of this, there may have been (very) moderate contamination of control students, but only based on the assumption of the temporal stability of teachers' support practices in the use of digital media. However, the control group's exposure to the intervention, where present, is negligible compared to the increase in teacher support reported by treated students ($w1 = 41.9[39.6; 44.2]$; $w2 = 68.5[66.4; 70.5]$; $p < 0.001$). Hence, we can reasonably rule out significant threats to the internal validity of the experiment due to contamination.

2.4. Data collection

In November 2017, without being informed that they would be participating in the project as a treatment or control group, students from all the recruited classes were asked to take a digital competence test and to fill in a questionnaire on their socio-demographic characteristics, uses, perceptions and attitudes towards new media and their well-being. Students were surveyed in the multimedia laboratories of the schools using CAWI methodology (Computer Assisted Web Interviewing), during the school day and under the supervision of external observers appointed and trained by the research group (who were not aware of the classes' experimental condition).

The second wave of data collection involved all students after the end of the intervention, in May 2018 (once treated teachers had completed all the media education activities). On this occasion, they were asked to retake the digital knowledge test and fill in the questionnaire again, using the same method and procedures adopted in the first wave. It is important to underline that also in this case students were not informed about their experimental condition and could not connect the assessment to the intervention, as the questionnaires were presented to them as part of a different academic research process, without any reference to the DWB-S project. The research assistants in charge of administering the questionnaires were also not aware of the experimental condition of each class.

In the first wave of data collection, the test and questionnaire were administered to a total of 3361 students, achieving a response rate of 92% (see Fig. 1). On this occasion, missing respondents were only students randomly absent on the dates of the survey. The second wave of data collection recorded a loss of 11% students compared with the first wave and a total loss of 18% compared with the targeted population. This drop can be attributed in part to students being withdrawn from schools or giving up their course, and in part to the higher number of absences that tend to characterise the end of the school year. However, no signs of differential attrition were found across the experimental groups, with losses ranging from 12% of those allocated to the intervention to 11% for the control group.

[5] We planned an additional training session for the comparison group after the end of the trial, to provide access to the intervention to all the teachers and students initially excluded from the treatment. The idea behind this was to prevent ethical concerns and scepticism about the project, ensuring compliance with the principle of equality in educational opportunities.

Table 1
Equivalence between control and treatment groups on covariates measured before the intervention.

	Individual level				Class level	
	Controls (n = 2.572)		Treated (n = 789)		Controls (n = 130)	Treated (n = 41)
	M (SD)	%	M (SD)	%	M (SD)	M (SD)
Socio-demographic:						
Female		51.8		51.5	51.7 (28.7)	51.0 (29.4)
missing		-		-	-	-
Migrant (1st and 2nd gen.)		12.9		12.4	13.5 (11.9)	12.9 (12.7)
missing		*0.6*		*0.4*	-	-
Age of respondent in years	15.2 (0.6)		15.2 (0.6)		15.2 (0.2)	15.2 (0.3)
missing		-		-	-	-
Family educational level						
Low (up to lower secondary)		10.0		10.7	11.7 (9.6)	12.8 (12.0)
Middle (upper secondary)		44.2		40.7	48.7 (14.2)	45.5 (15.2)
High (tertiary)		37.9		41.7	39.6 (17.2)	41.7 (17.9)
missing		*7.9*		*7.0*	-	-
Internet and smartphone:						
Internet connection at home		97.3		98.0	97.2 (4.4)	98.0 (2.9)
missing		*0.1*		-	-	-
Smartphone ownership		98.4		98.9	98.4 (3.6)	99.0 (2.0)
missing		*0.1*		-	-	-
Age access smartphone	11.3 (1.5)		11.3 (1.5)		11.3 (0.4)	11.3 (0.4)
missing		*1.6*		*1.1*	-	-
Mobile internet connection		92.1		91.4	93.4 (6.4)	92.0 (8.2)
Missing		*1.6*		*1.3*	-	-
Parenting style: limit internet use		44.7		45.3	44.5 (14.0)	45.1 (9.9)
Missing		*0.4*		*0.1*	-	-
Parenting style: discuss internet use		50.8		49.8	50.9 (12.5)	50.5 (12.3)
missing		*0.5*		*0.3*	-	-
Education:						
Type of school		0.4		0.4	–	–
Lyceum		53.1		53.0	50.0 (50.2)	48.8 (50.6)
Technical Institute		33.7		32.6	35.4 (48.0)	34.2 (48.0)
Vocational school		13.1		14.5	14.6 (35.5)	17.1 (38.1)
missing		-		-	-	-
Grade point average (0-10)	6.5 (1.1)		6.5 (1.0)		6.5 (0.4)	6.4 (0.4)
missing		*0.7*		*0.6*	-	-
Rejected at least for one year		18.2		17.4	19.7 (16.3)	18.2 (16.2)
missing		*0.4*		*0.4*	-	-

2.5. Outcomes

All the outcomes used in the study were measured before and after the intervention at student level - both in the treatment and control group - and normalised to a 0–100 scale.[6] Here we briefly report the key feature of each outcome, while the supplementary materials offer a more detailed description of their contents and statistical properties.

Perceived teacher support. Teachers' support in the use of digital media was measured with a battery of seven dichotomous items asking students whether they felt they had received specific forms of help from their teachers since the beginning of the school year. The items were designed *ad hoc* to measure students' exposure to the media education activities carried out by teachers in each of the training modules.

Smartphone pervasiveness. Smartphone pervasiveness in students' daily life was measured using the Smartphone Pervasiveness Scale for Adolescents (SPS-A) (Gerosa et al., 2022). The SPS-A consists of a battery of seven items asking respondents how frequently they use their devices at various times of the day that could be negatively affected by excessive smartphone use (e.g. at dinner with family, while studying, while talking with friends, at night when awake). Media use at such moments could affect sleep quality and give rise to loss of attentiveness and concentration, feeling of loneliness, social exclusion and even depression. All these symptoms could produce consequences on individuals' well-functioning (e.g. Przybylski & Weinstein, 2013; Pancani et al., 2021; Christensen et al., 2016; Demirci et al., 2015).

Problematic smartphone use. Perceived smartphone problematic use was measured by extracting the two sub-dimensions of *disturbance of adaptive functions* and *withdrawal* from the Smartphone Addiction Scale – short version for adolescents (Kwon et al., 2013) and the Smartphone Addiction Proneness Scale (Kim et al., 2014). Disturbance of adaptive functions consists of five items

[6] Our analyses are all related to the pre-registered primary outcomes (Digital knowledge and skills; Smartphone pervasiveness in students' daily life; Problematic digital media use; Types of internet use; Tangible outcomes of internet use; Perceived teacher support in digital media use). In addition we use general well-being, which was however one of our pre-registered secondary outcomes.

measuring the perceived negative consequences of smartphone use on respondents' ability to get along in their social environment with the most success and least conflict with others (e.g., I sometimes miss my planned work due to smartphone use). Withdrawal was instead defined by five items on perceived difficulties in managing abstinence from using a smartphone (e.g., I feel impatient and fretful when I am not holding my smartphone). The items of both scales focussed on the sub-dimension of *overuse* were instead excluded from the analysis due to their partial overlapping with the SPS-A. The latter was preferred because it allowed us to measure the frequency of smartphone use in relevant daily-life moments without encroaching on the issue of individuals' awareness of when the use of this device effectively becomes overuse (e.g., Panova & Carbonell, 2018). Finally, the items measuring *disposition toward cyberspace-oriented relationships* were excluded because acting on students' virtual life orientation was out of the scope of the DWB-S intervention.

Digital competence test. Students' digital competence was measured through a standardised test composed of 32 multiple-choice items based on realistic stimuli and situations that young people may encounter when using a smartphone or other devices connected to the web. This test focuses on quantifying the level of awareness respondents have in searching for, using and producing information, in communicating, and in safely handling their online experience and identity (Van Deursen & Van Dijk, 2014). Similar to the training materials, the test is also available free of charge for Italian teachers in the project platform[6]

Capital-enhancing internet and digital media use. By capital-enhancing use, we mean ways of using media based on strategies able to increase the social and cognitive opportunities of users (Hargittai & Hinnant, 2008). This study includes three multi-item measures of capital-enhancing activities, respectively focused on the use of the internet for information purposes, the creative use of digital media, and the interactive (as opposed to passive) use of social media. Based on previous research on tangible outcomes of internet use (Helsper, Van Deursen, & Eynon, 2015), we focused on four items, asking students whether their use of the web effectively contributed to an increase in their knowledge of specific topics, to forming opinions on specific issues and to learning new things about different cultures. The index of creative use is instead derived from three items measuring the frequency with which respondents engage in the creation and sharing of original digital content (Ekström & Östman, 2015). Finally, the interactive use index consists of four items measuring how often they publish content or interact with other users on social media (Escobar-Viera et al., 2018).

General well-being. General well-being was measured with the original version of the satisfaction with life scale (Diener et al., 1985), which focuses on five items for the self-assessment of overall life satisfaction and is well suited for use also with adolescents.

2.6. Analytical strategy

The impact of DWB-S on the selected outcomes was estimated using an Intention-To-Treat approach (ITT), suitable in our case thanks to low participant non-compliance/dropout and the lack of contamination (Hollis & Campbell, 1999), and also because they are the most informative estimates when evaluating a real world intervention and its normally imperfect implementation (as recommended also by the What Works Clearinghouse, 2022). The ITT models were estimated at student level using ordinary least square (OLS) regression models, introducing randomisation blocks and baseline values of each outcome as covariates and clustering coefficient standard errors at class level, as is normally the case in experimental studies (Hayes & Moulton, 2017). All impacts are reported both in terms of their raw regression coefficient and Cohen's D effect sizes, in order to maximise magnitude comparability (Cohen, 1988).

Regarding impact heterogeneity on gender bases, we simply replicated previous OLS models introducing an interaction term between treatment and student gender.

Table 2
Effects of the intervention on the outcomes measured at the student level: predicted average scores of by experimental group, adjusted OLS model estimates and effect size.

	Predicted average score		ITT	ESs
	Controls	Treated		
Perceived teacher support	41.6 (0.8)	68.1 (1.5)	26.5*** (1.7)	0.873 [0.785; 0.960]
Time management				
Smartphone pervasiveness	42.5 (0.4)	40.0 (0.7)	−2.6*** (0.8)	−0.183 [-0.268; −0.098]
Disturbance of adaptive functions	36.2 (0.4)	34.2 (0.6)	−2.0** (0.7)	−0.117 [-0.202; −0.032]
Withdrawal	28.5 (0.4)	27.3 (0.7)	−1.3 (0.8)	−0.075 [-0.160; 0.010]
Content management				
Digital competence test	50.8 (0.2)	51.2 (0.5)	0.4 (0.5)	0.035 [-0.050; 0.120]
Tangible outcomes of internet use	64.2 (0.4)	62.9 (0.7)	−1.4 (0.8)	−0.063 [-0.148; 0.022]
Creative media use	11.1 (0.8)	11.2 (0.9)	0.1 (1.2)	0.058 [-0.027; 0.143]
Active social media use	30.5 (0.6)	28.8 (0.8)	−1.7 (1.0)	−0.105 [-0.190; −0.020]
General well-being				
Satisfaction with life	54.6 (0.3)	55.0 (0.6)	0.4 (0.7)	0.037 [-0.048; 0.122]

Notes: standard errors clustered at class level in round parentheses. 95% confidence intervals in square parentheses. ***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$.

3. Results

Table 2 shows the estimates of the DWB-S impacts at student level. Here we report the average predicted scores for both treated and control groups at the end of the intervention, controlling for blocking variables and pre-intervention measures. We report the Intention-To-Treat estimates and their respective effect sizes (ESs).

The first column of the table focuses on perceived teacher support in the use of digital media, as a proxy for students' effective exposure to the training contents. Our estimates confirmed that, net of the baseline outcome values, treated students perceived a significant increase in teachers' support compared with the control group (26.5, $p < 0.001$), resulting in the rather large ES of the intervention (0.873). This relevant gain in teachers' support can be read as a proof of the effective implementation of the training experience in the class (H1).

Moving onto the impact of the intervention on smartphone time management, we found a moderate but significant reduction in the frequency of smartphone use during relevant moments of the day in treated students (-2.6, $p = 0.001$, $ES = -0.183$). In line with this result, we also found a significant decrease in mobile media-related disturbances of treated students' adaptive functions (-2.0, $p = 0.006$, $ES = -0.117$), while no relevant evidence emerges concerning smartphone withdrawal. Based on these results, we can partially confirm our expectations around the effectiveness of the intervention in reducing smartphone pervasiveness and its negative consequences on daily activities (H2).

With regard to the third research hypothesis (H3), we evaluated whether students' participation in such media education activities could contribute to an increase in their overall ability to manage online information, relationships, and content in a context of intensive connectivity. Moreover, we expected treated students to adopt online capital-enhancing strategies aimed at increasing their social and cognitive opportunities more frequently. Despite our expectations being based on the intervention logic, analyses show the absence of any relevant consequence of the intervention on these outcomes. Similarly, treated students' overall satisfaction with life did not vary significantly compared with the control group. We must therefore reject the hypothesis of a significant indirect effect of the intervention on students' general well-being (H4).

Moving to the analysis of gender differences, Table 3 shows that there are relevant pre-intervention variations between male and female students in most of the outcomes of interest.

In line with what is stated in H5, before the intervention females appeared to be more exposed than males to smartphone pervasiveness ($\Delta M = 2.6$, $p < 0.001$), perceived higher disturbance of adaptive functions ($\Delta M = 3.0$, $p < 0.001$) and, most of all, reported higher levels of smartphone withdrawal ($\Delta M = 8.0$, $p < 0.001$) and lower satisfaction with life ($\Delta M = 5.9$, $p < 0.001$).

The subsequent set of adjusted OLS ITT models, the results of which are reported in Table 4, introduced an additional interaction term between the treatment and a dummy variable distinguishing females from males, in order to study the Intention-To-Treat estimates conditional on the gender of respondents (H5).

We did not find relevant variations in perceived teachers' support across the two groups, with both males and females reporting significant but statistically equivalent estimates looking at the interaction term. This means that we can reasonably exclude gender-based differences in the effective exposure or sensitivity towards the media education activities carried out by teachers. Females reported significant estimates also for smartphone pervasiveness (-3.2, $p = 0.001$, $ES = -0.195$), disturbance of adaptive function (-2.9, $p = 0.002$, $ES = -0.188$) and digital competence (-1.0, $p = 0.038$, $ES = -0.045$), but, again, the variations registered by the interaction term remained statistically insignificant. Differential effects are also found in the area of withdrawal, with treated girls perceiving significantly lower levels of addiction to their smartphones (-3.2, $p = 0.004$, $ES = -0.191$). Unlike previous cases, they also registered a more consistent effect compared with their male counterparts (4.1; $p = 0.012$). Finally, we found a small but significant gender-based differences in the impact of the intervention on students' overall satisfaction with life, with an effect of 1.8 ($p = 0.021$, $ES = 0.123$) for females and a significant interaction term of 2.9 ($p = 0.050$) in their favour. It is interesting to note that such improvements perfectly mirror the relevant pre-intervention differences found among male and female students both in smartphone withdrawal and satisfaction with life. In this way, the effect of the trial manifests itself as a compensation of pre-existing gender-based digital inequalities. Thus, we can finally confirm H5 at least for these two outcomes.

Table 3
Gender differences in the distribution of baseline outcomes.

	Males	Females	*P*-value
Perceived teacher support	39.3 (31.6)	41.1 (28.3)	0.075
Time management			
Smartphone pervasiveness	42.9 (20.2)	45.5 (19.2)	0.000
Disturbance of adaptive functions	37.2 (22.2)	40.3 (23.8)	0.000
Withdrawal	28.0 (21.5)	36.0 (24.0)	0.000
Content management			
Digital competence test	48.2 (12.4)	47.6 (9.6)	0.092
Tangible outcomes of internet use	63.7 (22.5)	64.7 (20.6)	0.199
Creative media use	9.8 (20.1)	12.4 (26.4)	0.002
Active social media use	27.8 (21.5)	33.5 (21.4)	0.000
General well-being			
Satisfaction with life	57.3 (21.2)	51.4 (21.1)	0.000

Notes: standard deviations in round parentheses.

Table 4
Differential effects of the intervention across gender. Adjusted OLS interaction model estimates and effect size.

	Males		Females		Diff.
	ITT	ESs	ITT	ESs	
Perceived teacher support	25.8*** (2.4)	0.815 [0.688; 0.941]	27.1*** (2.1)	0.938 [0.816; 1.061]	1.3 (3.0)
Time management					
Smartphone pervasiveness	−2.0 (1.1)	−0.170 [-0.293; −0.048]	−3.2*** (0.9)	−0.195 [-0.312; −0.077]	−1.3 (1.3)
Disturbance of adaptive functions	−1.1 (1.2)	−0.035 [-0.158; −0.087]	−2.9** (0.9)	−0.188 [-0.306; −0.071]	−1.8 (1.5)
Withdrawal	0.9 (1.1)	0.066 [-0.056; 0.189]	−3.2** (1.1)	−0.191 [-0.309; −0.073]	−4.1* (1.6)
Content management					
Digital competence test	−0.3 (0.8)	0.026 [-0.096; 0.149]	1.0* (0.5)	0.045 [-0.073; 0.163]	1.3 (0.9)
Tangible outcomes of internet use	−0.7 (1.2)	−0.007 [-0.129; 0.116]	−2.0 (1.1)	−0.133 [-0.250; −0.015]	−1.3 (1.7)
Creative media use	1.6 (1.6)	0.010 [-0.113; 0.132]	−1.2 (1.1)	−0.113 [-0.230; 0.005]	−2.8 (1.5)
Active social media use	−2.3 (1.3)	−0.158 [-0.280; −0.035]	−1.2 (1.1)	−0.047 [-0.164; 0.071]	1.1 (1.4)
General well-being					
Satisfaction with life	−1.1 (1.1)	−0.060 [-0.183; 0.063]	1.8* (0.8)	0.123 [0.005; 0.241]	2.9* (1.5)

Notes: standard errors clustered at class level in round parentheses. 95% confidence intervals in square parentheses.
***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

4. Discussion

This study sought to evaluate the feasibility and effectiveness of a newly developed teacher training package for the promotion of a conscious, strategic, and responsible use of mobile media among high school students. A first relevant aspect of the DWB-S programme consisted in the attempt to make teachers autonomous in planning and implementing media education activities in their own classes, in order to increase students' opportunities to be exposed to, reflect on and discuss the training contents throughout the school year. The high levels of teachers' compliance we detected, together with the substantial increase in the support they offered to treated students in the use of digital media over the year, suggest that interventions like DWB-S can be successfully implemented in a high school setting. This result supports the literature suggesting directly involving teachers in school-based media education projects, as a valid alternative to spot interventions led by external trainers (Walther et al., 2014; Vondráčková & Gabrhelik, 2016; Gordon et al. (2021).

Moving on to the impact of the intervention on student-related outcomes, we found a significant decrease in smartphone pervasiveness and its negative consequences on adaptive functions in the treated group. These results indicate that the intervention had an impact on students' use of their smartphone during moments of daily-life that are particularly relevant for their psychosocial well-being. It also reduced the negative consequences this device can have on their ability to get along in social environments with the most success and least conflict with others, confirming that training in mobile media management can be effective in reducing misallocated screen time (Bonnaire et al., 2019; Throuvala et al., 2020).

Conversely, the intervention did not lead to significant growth in students' online content management skills, active and creative digital media use or tangible outcomes of internet use. A possible interpretation of this lack of effects is that, while the consequences of the training course on time management and smartphone pervasiveness were able to manifest themselves in a one-year time frame, those of content-related digital skills need more time and training to emerge. This is in line with the literature on behavioural change showing that habits can be modified in a relatively short time (Lally et al., 2010), while learning digital skills is a longer and more complex developmental process (Van Deursen & Van Dijk, 2014).

Regarding the interpretation of gender differences, females appeared to be more prone to problematic smartphone use before the intervention and showed significantly greater benefits from their participation, both in terms of reduced withdrawal symptoms and increased general well-being. These results expand recent findings that girls are more exposed to the risk of problematic smartphone use and, at the same time, are more responsive to digital media education (Gordon et al., 2021) also in this specific domain. Consequently, interventions such as ours seem able to reduce the gender gaps in problematic smartphone use that have emerged in the literature in recent years (see Busch & McCarthy, 2021; Demirci et al., 2015; Lin & Chiang, 2017). As these results confirm a significant gender-based difference in how young people deal with permanent connectivity and react to interventions about it, future research will have to throw light on the reasons behind such differences.

Despite its limitation to girls, the impact of the intervention on subjective well-being is worthy of separate discussion. Indeed, this piece of evidence is particularly relevant. First of all, as far as we know, the present study is the first to present evidence of the beneficial impact of mobile media education on general well-being. In particular, the joint effect of the trial on both problematic smartphone use and general well-being raises the question of what is the exact causal chain behind this evidence. Although we cannot confirm the existence of a causal path connecting a lower problematic smartphone use to a higher general well-being, the results suggest that this could be an interesting hypothesis to properly test. This hypothetical causal link seems supported by related empirical literature showing that a number of psychological constructs such as self-control, attention management, mindfulness and self-regulation are relevant for mobile media use (e.g., Bayer et al., 2016; Hefner et al., 2018; Karsay & Vandenbosch, 2021; Levy, 2016; Schneider et al., 2022). All these variables are also related to general well-being and therefore they could be tested as additional intervening factors. Future research can address these questions, helping to shed light on the important but still widely debated issue of the effect of digital media use on well-being (see for example Johannes et al., 2022; Valkenburg, Meier, & Beyens, 2022).

This study has two main limitations. The first concerns the self-reported nature of mobile media use and its consequences among

the adolescents we used in our analyses. This may be subject to estimation biases due to individual difficulties in reporting habitual checking behaviours and actual misuses (Gerosa et al., 2022; Wilcockson et al., 2018), even if data collection for students was not related to the intervention. Future research in this field should invest more in the integration of traditional survey instruments with objective measures of smartphone frequency and type of use, moving for example towards trace data obtained from online monitoring apps (e.g. Felisoni & Godoi, 2018; Kim, Kim, et al., 2019). Gathering such data can be challenging in several areas (Kreuter et al., 2020; Stier et al., 2020), especially when large predefined samples of minors are studied (e.g., selection bias for technological limitation; complex procedures in place to obtain explicit and informed consent). However, trace data is a promising source not only for overcoming the issue of bias in self-reports on the amount of time spent on the devices, but also for collecting additional information on smartphone-related interferences, such as checking habits or notifications (Kushlev & Leitao, 2020).

A second limitation, typical of randomised trials, is the lack of external validity of our results. As stated in the paper, descriptive statistics about our sample, its size and variability mean we are confident that we were not intervening in a highly unusual context. Nonetheless, replications of the trial in other schools and national settings would appear to be crucial in order to learn more about interventions in this emerging field. Hypothesising that mobile media education interventions can become a structural part of school curricula, it would also be important for future research to understand their effects on different outcomes, within an entire school system and in the long run.

5. Conclusions

In this paper, we have described the motivation, theory, methodological design, and results of a cluster randomised trial assessing the impact of Digital Well-Being - Schools on youth smartphone usage habits and online content management, also evaluating its consequential causal impact on participants' well-being.

The programme was implemented as expected and the internal validity of the experiment was preserved. Our results lead to the conclusion that improving time and attention management with mobile media is a promising area of work for media education interventions of this type and duration. In particular, since time and attention management are emerging in the public debate as core challenges within a constant connectivity environment, the activities proposed (especially in module 1) can be important components of short-time media education interventions for young people.

These results proved the effectiveness of the intervention's approach concerning problematic smartphone use. The logic behind it was to provide students with "media awareness experiences" within a limited number of hours, followed by the establishment of *good habits* to be developed with students and referred to throughout the academic year. We believe this solution has contributed to reinforce the impact of the intervention well beyond the 12 h of classroom activity. Based on the high compliance that emerged and the strong growth in the perceived teacher support among treated students, it is not rash to say that the intervention turned out to be sustainable for teachers as a complement to and integration of their daily activities. In particular, the direct involvement of teachers in digital media education activities seems to offer a deeper and lasting exposure of students to the educational content, the establishment of good media habits on a daily basis, the emergence of links between media education and curricular disciplines and, last but not least, the exploitation of complementarity in the skills of students and teachers (the former more at the technical-operational level, the latter more at the critical-reflective one). We suggest making use of a habit-based approach in mobile media education in order to consolidate its results in the form of real new routines.

On the contrary, the lack of beneficial effects on content-related skills in the overall sample can drive future research to understand whether these skills simply need a greater time span to manifest a measurable increase, or whether other types of educational content may be more effective for this purpose. However, given the relevance of problematic smartphone use among young people, we suggest that teacher training as the kind presented here be included in the curricula of schools and other educational institutions.

Credit author statement

Marco Gui: Supervision, Funding acquisition, Project administration, Conceptualization, Writing- Reviewing and Editing Tiziano Gerosa: Conceptualization, Investigation, Data curation, Formal Analysis, Methodology, Writing-Reviewing and Editing Gianluca Argentin: Methodology, Reviewing and Editing Lucilla Losi: Resources, Editing.

Data availability

The data will be freely available here https://www.unidata.unimib.it

Acknowledgments

We thank the funders of the "Benessere Digitale - Scuole" project: the Italian Ministry of Education in the context of the "Piano Nazionale Scuola Digitale ("Curricoli Digitali" tender), the University of Milano Bicocca ("Innovation Project Grant 2016"), Fastweb, the network of schools led by "Liceo Banfi" in Vimercate (Italy). We acknowledge the precious work of Andrea Garavaglia, Livia Petti and Marco Fasoli in the initial phase of the project. Our thanks are also due to the members of the steering group who supervisioned the experiment: Maria Ranieri, Antonio Fini, Simone Giusti, Alberto Pellai, Gabriella Taddeo. We also thank all the students and teachers who participated in the project, in particular Fabio Marca and Vincenzo Di Leo.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compedu.2022.104705.

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