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ORIGINAL PAPER

Examining the Impact and Moderating Effects of an 8-Week Mindfulness-Based Program in Grade 4

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Abstract

Objectives There is a growing interest in mindfulness-based programs. Yet, research in the area is limited, and little is known about the factors that moderate the effects of these programs. The two-fold aim of this study was (1) to examine the effects of a mindfulness-based program on dispositional mindfulness, inattention and emotional lability, handwriting fluency, spelling accuracy, and composing quality, as well as school achievement; and (2) to evaluate the moderating role of lesson absences, intervention-related knowledge, and social validity.

Method Using a quasi-experimental design, 257 fourth graders were assigned to an experimental group receiving a mindfulness-based program ($n = 130$) or an active control group receiving a health-based program ($n = 127$). Both programs were implemented in the classroom for 8 weekly units, which included two 30-min sessions delivered by psychologists, followed by three 5-min sessions delivered by teachers. All children were evaluated before and after the programs.

Results Compared to the control condition, the mindfulness-based program resulted in higher levels of internal and external awareness, and decentering and nonreactivity, as well as better composing quality and mathematics grades. Lesson absences, intervention-related knowledge, and social validity did not moderate the effects of the mindfulness-based program.

Conclusions These findings support the integration of mindfulness practices in primary school as a means to improve children's academic-related skills and ability to be mindful.

Keywords Mindfulness · Children · Intervention · Achievement · Moderators

Mindfulness is defined as a moment-to-moment awareness that arises through paying attention to the present moment, with a non-reactive, non-judgmental, and openhearted attitude (Kabat-Zinn, 2005). Research showed that promoting this kind of awareness in adults improves proximal outcomes, such as mental health conditions and executive functioning (Klainin-Yobas et al., 2012; Poissant et al., 2020), as well as distal outcomes, such as college performance (Lin & Mai, 2016). Recently, there has been an interest in developing and testing mindfulness-based programs (MBPs) for young populations (Emerson et al., 2019).

MBPs aim to increase attention to thoughts, emotions, and sensations, without judging or reacting to them (Semple et al., 2010; Zelazo & Lyons, 2012). Despite the varying structure, many evidence-based MBPs have a median duration of 8 weeks, with 45-min sessions once a week or shorter sessions several times a week (Pickerell et al., 2023; Semple et al., 2016; Zenner et al., 2014). A core mindfulness practice in MBPs is meditation. This is a form of mental training

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that can be classified by level of activation and body orientation (Matko & Sedlmeier, 2019). For example, low activation and body orientation techniques involve cultivating compassion and visualizations, concentrating on an object, and contemplating a question or paradoxes. High activation and body orientation techniques include meditations with movement, breath manipulation, and senses observation (Matko & Sedlmeier, 2019). Typically, meditation is combined with reflective practices (e.g., psychoeducation, group discussions) focused on the program's concepts and their generalization (Semple et al., 2016). Though coupling meditation and reflective practices is common to all MBPs (Zenner et al., 2014), the operationalization of these practices must consider participants' age. MBPs for children should involve short meditations with some degree of activation and body orientation, explained through clear instructions and concrete metaphors (Zelazo & Lyons, 2012).

The exact age at which MBPs may be used remains unclear (Amundsen et al., 2020), and it has been suggested that they may be useful in developmental transitional periods characterized by significant cognitive and socio-emotional changes, such as middle childhood (Maloney et al., 2016; Rempel, 2012; Tyler, 2020). Between 7 and 11 years, children face a major turning point in their cognitive and socio-emotional development, described by Piaget (1964) as the concrete operational stage. Here, children develop a more logically and conceptually based thinking. Egocentrism begins to disappear as the understanding of others' perceptions increases, resulting in greater social perspective-taking (Enright & Lapsley, 1980; Piaget, 1964). There are marked increases in children's ability to retain and manipulate information in mind, to pay attention to internal and external stimuli, and to use memory strategies (Tyler, 2020). This is a decisive period in the development of children's ability to self-regulate their thoughts, actions, and emotions (McClelland et al., 2018).

According to Cunningham and Zelazo (2007), this growth in self-regulation relies on the interaction of reflexive and reactive processes: On the one hand, information is dynamically processed through iterative loops, allowing an increasingly deep reflection of experiences (top-down processes); on the other hand, this top-down control is either facilitated or hindered by bottom-up influences, like stress, arousal, and anxiety. Based on this developmental socio-cognitive neuroscience perspective, Zelazo and Lyons (2012) proposed that MBPs operate by (a) promoting top-down processes (e.g., controlled attention) through the training of attention to present experiences, and (b) mitigating bottom-up influences (e.g., anxiety) through the nurturing of non-judgmental and nonreactive attitudes.

The end of primary school may represent a suitable moment to implement MBPs. Though children may possess the necessary self-regulation and perspective-taking skills to engage in mindfulness training (Kabat-Zinn, 2005), these skills are not yet fully acquired, and they are sufficiently malleable to be shaped by this type of training (McClelland et al., 2018; Zelazo & Lyons, 2012). Grounded on the theory of change developed by Roeser et al. (2020), MBPs have been proposed to impact the proximal outcomes of mindfulness and self-regulation, which in turn may influence school-related distal outcomes.

Dispositional mindfulness refers to individuals' capacity to be mindful, which may involve multiple facets (Brown & Ryan, 2003), such as awareness of internal and external experiences, acting with awareness, accepting and non-judgmental orientation, decentering and nonreactivity, openness to experience, relativity of thoughts, and insightful understanding (Johnson et al., 2017). A meta-analysis with 5,787 adults found that MBPs not only increased participants' abilities to pay attention to the present ($g = 0.44$) and notice sensations ($g = 0.47$) but also decreased their tendencies to judge ($g = 0.44$) and react to difficult situations ($g = 0.49$; Quaglia et al., 2016). Similar benefits were reported in a pilot study with 20 adolescents ($M_{age} = 12.1$; $SD = 1.3$), but effect sizes were not reported (Hafeman et al., 2020).

Another proximal outcome of MBPs is attention and emotional regulation, which was moderately-to-largely impacted by MBPs, as reported by studies with samples ranging from 31 to 246 participants ($\eta_p^2 = 0.12$–0.49; Crescentini et al., 2016; Magalhães et al., 2022; Schonert-Reichl and Lawlor, 2010). Yet, a meta-analysis with 1,348 students in Grades 1–12 reported non-significant effects of MBPs on parent- and teachers' ratings of attention-related aspects and on self-reported emotional problems (Zenner et al., 2014). This work highlighted the importance of using of multi-informant data (i.e., parents, teachers, children) to assess MBPs' effects, as it reduces measurement error, allow comprehensive assessments, and provides stronger evidence (Ridderinkhof et al., 2018; Whitcomb & Merrell, 2003).

It is assumed that these benefits on proximal outcomes result from the combination of meditation and reflective activities, a key feature of MBPs. These activities help individuals to decenter from automatic behaviors, beliefs, and feelings, while developing interoceptive awareness and reducing experiential avoidance (D'Antoni et al., 2022). They also improve self-regulation through the practice of sustained and non-judgmental awareness. According to Zelazo and Lyons (2012), by supporting top-down processes and attenuating bottom-up influences, MBPs may result in enhanced attention and emotional regulation abilities.

A relevant distal outcome of MBPs is school success (Dunning et al., 2019), typically indexed through specific academic skills, such as writing, or school grades (Roeser et al., 2020). Writing is an objective indicator of academic

achievement, as it is the main tool to acquire, share, and evaluate knowledge (Goldstein & McGoldrick, 2021). In primary school, writing is dependent on students' transcription skills, namely, their abilities to produce words fast (i.e., handwriting fluency) that follow orthographic conventions (i.e., spelling) (Cordeiro et al., 2020; Magalhães et al., 2020). Recently, Cordeiro et al. (2022) showed that along with these skills, mindfulness could influence writing. The authors proposed that, in a demanding task like this, the enhanced focus and positive attitudes of mindfulness could support transcription and help young writers to produce better texts. A few experimental studies attempted to relate mindfulness to writing. Cordeiro et al. (2021, 2022) reported that, compared to third graders participating in a relaxation program ($n = 37$), those participating in an MBP ($n = 29$) had greater handwriting fluency with a medium effect size ($\eta_p^2 = 0.09$). Yet, no effects were found for spelling and text quality (see also Bakosh et al., 2015; 2018; Magalhães et al., 2022).

As another distal outcome of MBPs, school grades have received moderate research attention. In the study of Cordeiro et al. (2021), mindfulness (vs. relaxation) training resulted in better grades in the subject of portuguese, with a medium effect size ($\eta_p^2 = 0.07$). Another randomized trial showed that mathematics and social studies grades and Grade Point Averages were higher among students in an MBP ($n = 167$) than those in a wait-list group ($n = 170$), but effect sizes were generally low (Bakosh et al., 2018). Recently, Magalhães et al. (2022) also reported MBP ($n = 28$) benefits with medium effect sizes ($\eta_p^2 = 0.07$–0.12) on different school subjects (viz., Portuguese, mathematics, and social studies) over a health-based program ($n = 29$). Despite that, a meta-analysis with 6,207 students reported no significant effects of MBPs on academic outcomes (Maynard et al., 2017). It must, however, be kept in mind that this conclusion was based on five studies targeting preschool and primary school children, not exclusively focused on mindfulness (some studies included yoga training) and not including the above-cited research.

There is no sound evidence about the mechanisms underlying MBPs' benefits on distal outcomes. It has been suggested that MBPs are expected to increase school-related distal outcomes due to their association with executive functions. Likely through their impact on top-down and bottom-up processes (Zelazo & Lyons, 2012), mindfulness training has been found to enhance executive functioning (Dunning et al., 2019), which is essential for writing (Limpo & Olive, 2021) and school achievement (Razza & Raymond, 2014).

Taken together, available findings are promising but not enough to make strong claims about MBPs benefits in children. Also, little is known about the factors that may moderate these effects. If the evidence on the moderating role of participants characteristics is reduced (but see Gould et al., 2012; Magalhães et al., 2022), that of intervention-related characteristics is almost non-existent. Yet, research from related fields and/or adults suggested that number of lesson absences, knowledge acquired during MBPs, and children's perceptions about the program's value may affect MBPs effectiveness. Information on these moderators has a great applied value, providing relevant data on the level of importance of students *attending* all lessons to *retain* key contents *valued* by them.

Without compensation, when students miss an MBP lesson, the contents are not conveyed, and the meditation exercises are not performed. Thus, it seems reasonable to expect that the more lessons are missed, the less effective is the program (Cayoun, 2011). Indeed, Scott-Hamilton and Schutte (2016) found that a mindfulness intervention for adults had less impact on participants who attended fewer sessions and had fewer meditation time.

During MPBs, participants are expected to learn knowledge in reflective activities (Zenner et al., 2014). Still, the effective acquisition of that knowledge and its role in MBPs' effects is unknown. Botta et al. (2015) showed that adults acquired relevant knowledge during an MBP, but they did not examine whether that influenced the intervention's effectiveness. This hypothesis is aligned with Birrer et al. (2012), who proposed that greater knowledge about mindfulness could increase the impact of mindfulness training.

Another potential moderator of MBPs' effects is social validity, that is, the degree to which participants perceive the programs as acceptable, relevant, and useful (Carter & Wheeler, 2019). Possibly, those who engage in mindfulness practices may value them more (Grossman & Van Dam, 2011), which may facilitate its benefits, by prompting committed and systematic practice. Though one study showed that a child protection intervention for teachers was more effective among those with greater levels of acceptability (Kim et al., 2019), it is unknown whether these findings generalize to children allocated to MBPs.

All in all, despite the growing interest in MBPs' effects, many limitations persist. Research with children is less than that with adolescents and adults (Crescentini et al., 2016). Available findings are mixed (Emerson et al., 2019) and often obtained from clinical samples without a priori power analysis (Huguet et al., 2019). Several studies neither included active controls (Gould et al., 2012) nor studied moderators of effectiveness (Schonert-Reichl & Lawlor, 2010). Finally, only a handful of studies tested the impact of MBPs during global stressful events. To move the field forward, we conducted the present quasi-experimental study during the COVID-19 pandemic in a sample of Portuguese fourth graders. We compared children participating in an MBP (MBP group) with children participating in

a health-based program (HBP group). This is a common control condition, including nutrition and physical activity components to enhance health and well-being, but lacking mindfulness-related ingredients (MacCoon et al., 2012). Both intervention programs were implemented in face-to-face classroom groups during 8 weekly units, with two 30-min sessions delivered by psychologists, followed by three 5-min sessions delivered by teachers.

The primary research question (RQ) was: Is an MBP effective in improving fourth graders' dispositional mindfulness, teacher-rated children's behavior, writing performance (i.e., handwriting fluency, spelling errors, and composing quality), and academic achievement? Based on past evidence and MBPs features, we expected the MBP group to surpass the HBP group in terms of dispositional mindfulness, attention and emotion regulation, handwriting fluency, spelling errors and composing quality, and school grades.

The exploratory RQ was: Are the expected MBP effects moderated by the number of lesson absences, intervention-related knowledge, and social validity? Although no study to date tested the role of these moderators in MBPs for children, grounded on theoretical claims and empirical evidence from other fields, we expected the MBP to have stronger effects among children with fewer absences, more knowledge acquired, and higher social validity.

Method

Participants

A flow diagram of the study participants is presented in Fig. 1. The interventions were delivered to 321 students from 15 to 4 classrooms from two public schools in Northern Portugal. In both schools, classroom groups were assigned to the MBP and HBP groups. To ensure a balanced sample size across groups, we used a stratified randomization procedure, with classroom size as the stratum. For ethical reasons, the interventions were embedded into the curriculum and delivered to all students during class time. The following exclusion criteria were set for defining the data analytic sample: lack of written consent from the legal guardian ($n = 36$, 11.2%), presence of special education needs ($n = 24$, 7.5%), and absence in all assessment tasks ($n = 4$, 1.3%). Despite these exclusions, 257 students were eligible. This sample size is consistent with a priori power analysis using G*Power 3 (Version 3.1.9.6; Faul et al., 2007), in which we specified power = 80%, $\alpha = 0.05$, and the use of multivariate analysis of variance (MANOVA). Results indicated a minimum of 255 participants to detect effects of small magnitude ($f^2 = 0.02$), as reported in the literature (Bakosh et al., 2015, 2018; Cordeiro et al., 2022; Zenner et al., 2014).

The MBP group included 130 students (69 girls, 53.1%) from eight classes, with an average age of 9.37 years

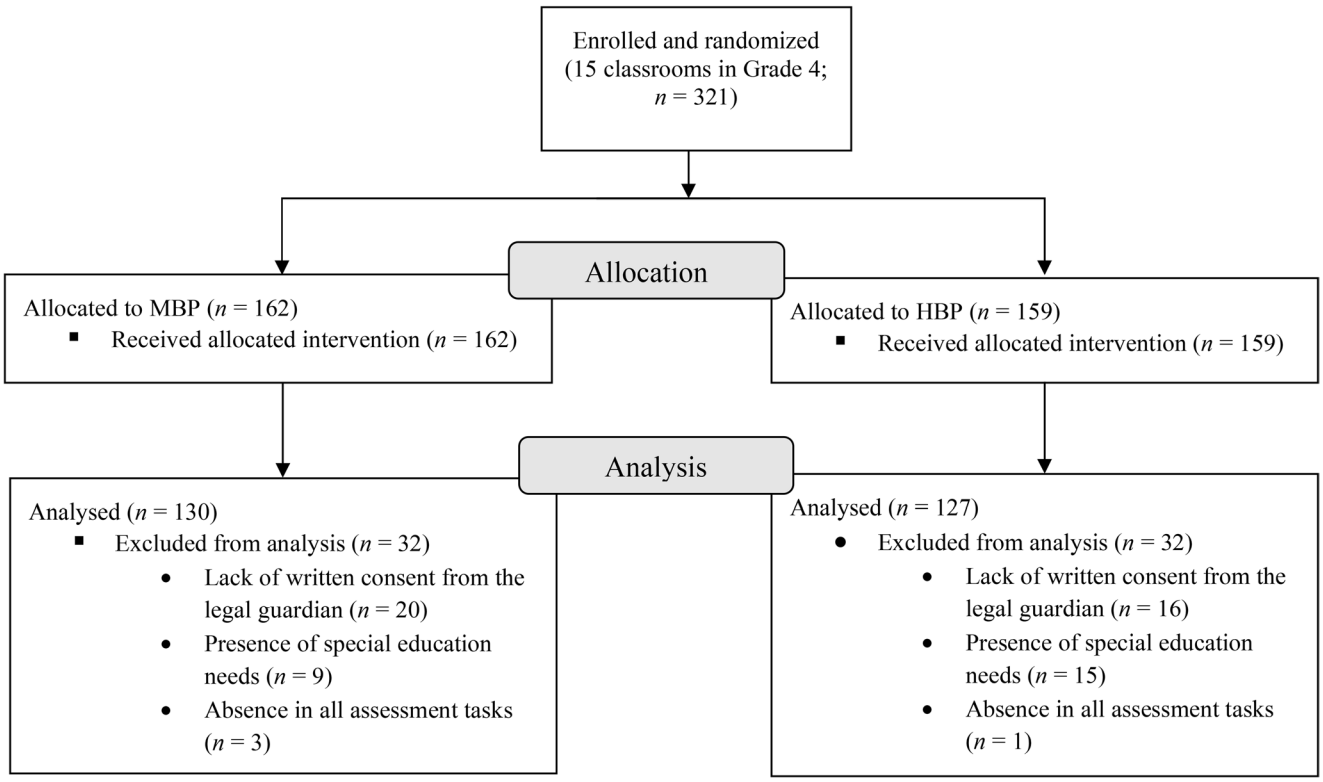

Fig. 1 Flow diagram of the study participants

(*SD* = 0.44), whereas the HBP group included 127 students (60 girls, 47.2%) from seven classes, with an average age of 9.29 years (*SD* = 0.33). The educational level of the children's legal guardians in the MBP and HBP groups was as follows: 3%/7% completed Grade 4 or below, 13%/19% completed Grade 6, 27%/31% completed Grade 9, 22%/26% completed Grade 12, 25%/12% were graduated, and 5%/4% were post-graduated (for 5%/1% information was unknown). Both groups did not differ in terms of gender, $\chi^2 = 0.87$, $p = 0.35$, age, $t = -1.71$, $p = 0.09$, and educational level of the legal guardian, $\chi^2 = 10.80$, $p = 0.06$.

Procedure

The goals of the study and conditions of participation were explained to all participants and their legal guardians. All children included in the data analysis received consent from their legal guardians and agreed to participate. The study was conducted from September to December 2020, during the COVID-19 pandemic. All students were evaluated before and after the interventions in 30-min classroom sessions in person. Firstly, they were asked to copy a sentence as quickly and legibly as possible for 90 s. Secondly, the experimenter conducted the spelling dictation task. Thirdly, the experimenter gave students 10 min to compose a text. Finally, they filled in the dispositional mindfulness scale. During the same week of classroom data collection, teachers filled in the inattention and emotional lability scales and provided students' school grades.

Interventions

Both intervention programs were implemented in classroom groups during 8 weekly units. Each unit involved two 30-min long lessons delivered by psychologists on Monday and Tuesday, followed by three 5-min short lessons run by the schoolteacher on Wednesday, Thursday, and Friday. Long lessons were supported by PowerPoint files with the key topics to present. Short lessons were also supported by a PowerPoint file, but the sole task of teachers was to open it and play an audio/video file.

Mindfulness-Based Program

The main goal of the MBP was to develop awareness and acceptance of the self, others, and the environment. The creation of this program followed the Framework for Developing and Testing Mind and Body Interventions published by the National Center for Complementary and Integrative Health, meanwhile integrated with the Stage Model of Intervention Development National Institute of Health by Saunders and Kober (2020), who offered stage-by-stage recommendations to develop and test evidence-based MBPs. Accordingly, in Stage 1, we deepened knowledge related to the features and effects of MBPs in youth populations (citation omitted). In Stage 2, we used this knowledge to develop a comprehensive and age-appropriate intervention program inspired by other effective MBPs (Bakosh et al., 2018; Crescentini et al., 2016). In Stage 3, the feasibility of this program was assessed to determine whether a full-scale efficacy trial could be conducted (citation omitted). Collected data was used to refine the program that was used in the current efficacy study (Stage 4).

The MBP was composed of 8 weekly units organized into six modules: *Introduction*, aimed to introduce the program, including its main goal (i.e., to develop students' awareness and acceptance of internal and external stimuli, thereby, helping them to be happier); *5 Senses*, aimed to promote mindfulness by paying attention to and enjoying the present moment using touch, sight, hearing, smell, and taste; *Body*, aimed to practice the observation of body sensations; *Heart*, aimed to practice the observation, identification, and acceptance of emotions; *Brain*, aimed to practice the observation and identification of useful and useless thoughts; and *Consolidation*, aimed to consolidate knowledge and close the program with a loving-kindness message (Magalhães et al., 2022).

All MBP long lessons had a similar structure, except the first and last ones (for an overview, see Table S1 in Supplementary Materials), aimed to introduce and close the program. The other lessons included the following sequence of activities: one meditation activity (5 min), revising, two or three meditation or briefing activities (total of 5–7 min), reflection, and conclusion. Whereas the revising, reflection, and conclusion moments were led by the psychologist, the meditation and briefing activities were implemented through an audio file.

The revising and conclusion moments were, respectively, aimed at recapping the learnings made in the previous lessons and integrating the new learnings into the newly acquired knowledge. In the meditation activities, children were guided to silently focus on the present moment by observing the surrounding environment or internal/external sensations. The briefing activities were used to introduce complex concepts addressed in the meditations. The reflection moments were aimed at confirming whether children understood what was addressed in the lesson using a question-answer game. Afterward, children filled in a progress sheet, in which they registered the number of correct answers given in each lesson and made a drawing of their favorite learnings in each module.

The MBP short lessons included an audio meditation played in the MBP long lessons of the week. These were aimed at practicing the focus of attention. At the last lesson

of the week, teachers presented a weekend challenge to promote knowledge generalization, whose completion was registered in the progress sheet.

Health-Based Program

The main goal of the HBP was to teach children about the importance of being healthy and to provide them with the means to achieve it. The program was based on the recommendations from the Portuguese Directorate-General of Health (2012). It was composed of 8 weekly units organized into three modules: *Introduction*, aimed to introduce the program, including its ultimate goal (i.e., to have more energy) and how to achieve it (i.e., eating healthy and doing exercise); *Inside and Outside the Food Pyramid*, aimed to provide children with knowledge to make healthy choices when eating; *Consolidation*, aimed to consolidate knowledge and close the program.

As the MBP, except the first and the last ones, all HBP long lessons had a similar structure (for an overview, see Table S2 in Supplementary Materials) with these sequential moments: stretching activity, revising, main activity, reflection, and conclusion. All activities were implemented by a psychologist, except the stretching activity, which was implemented through a video of two physical education teachers. There were four versions of these stretching activities, which were also used for the HBP short lessons. This program also included weekend challenges and self-monitoring activities.

Treatment Fidelity

We developed a 24-h course composed of an introductory, pre-intervention workshop of 9 h to introduce the bases of the programs, followed by a set of 90 min weekly monitoring sessions to discuss the lessons. To minimize contamination, psychologists and teachers were asked to not discuss the interventions outside these sessions. There were sporadic divergences from instructional plans involving missed steps, completed in the subsequent week. The course ended with a 3-h session to wrap up. All sessions were co-led by the first and third authors and attended by all psychologists and teachers involved.

Long lessons were organized into 14 main steps detailed in a checklist to be completed by psychologists. Except for one psychologist, who failed to implement one step in an MBP lesson (93% of completion), all others implemented 100% of planned steps. Four lessons in the MBP and HBP (i.e., 25% of the lessons) were audio-recorded and listened to by a trained research assistant, who reported that 100% of planned steps were completed. The same researcher also evaluated the content of the lessons implemented to confirm that they were conducted as expected in terms of fluency (i.e., lessons occurred smoothly without interruptions), interaction with students (i.e., students actively participated in the activities and were responsive to psychologists' requests), and quality (i.e., the psychologist kept the underlying idea of the step implemented). These evaluations were made using a scale ranging from 1 (*very low*) to 5 (*very high*). In the MBP and HBP groups, the average scores were 4.94/4.96 for fluency, 4.97/5.00 for interaction with students, and 5.00/5.00 for quality. In terms of students' adherence, in the MBP and HBP, respectively, there was an average participation in 14.98 ($SD = 1.69$) and 13.73 ($SD = 2.27$) lessons out of 16.

Short lessons included a single step, that of playing an audio meditation or a stretching video. Teachers were given a checklist to fill in at the end of the week, indicating whether the files were played. There were 24 short lessons planned, but due to the worsening of the pandemic situation, only 23 short lessons were implemented across all classes. All teachers implemented these 23 lessons, except three MBPs teachers (one teacher missed three lessons, and two teachers missed one lesson). In the MBP and HBP, respectively, there was an average participation in 21.88 ($SD = 2.11$) and 20.31 ($SD = 3.39$) lessons out of 23.

The implementation of the MBP in some classes was adjusted. Two weekly units in one class and three weekly units in another class were conducted online because the whole classes were sent home by the Portuguese Directorate-General of Health due to COVID-related situations. These online implementations were carefully followed by the research team, who assured that the fidelity of implementation was not compromised.

Measures

Dispositional Mindfulness We used the Comprehensive Inventory of Mindfulness Experiences (Johnson et al., 2017) validated to Portuguese by Magalhães and Limpo (2022) with a sample of 223 fourth graders (age 9–10). This instrument is composed of 21 items organized into seven factors (the original instrument has an eighth factor, which did not work in the Portuguese validation, and thus not used here): internal awareness (i.e., being aware of emotions), external awareness (i.e., being aware of the environment), acting with awareness (i.e., being aware of the present moment without being caught up in thoughts), decentering and non-reactivity (i.e., stepping back and avoid reacting to difficult emotions and thoughts), openness to experience (i.e., allowing the presence of difficult emotions and thoughts), relativity of thoughts (i.e., recognizing thoughts as subjective and temporary), and insightful understanding (i.e., recognizing that the interpretation of situations can create or worsen dif-

ficulties). Children were asked to indicate how often a set of situations occurred (e.g., "I noticed sounds in my environment, such as birds chirping or cars passing"), in a 6-point scale, ranging from 1 (*almost never*) to 6 (*almost always*). Higher scores indicate greater dispositional mindfulness in the respective factor.

Because we used multiple imputation of missing data, which resulted in five imputed datasets (see below Data-Analytic Strategy), we examined McDonald's omegas for the complete dataset and its median value for the five imputed datasets. When McDonald's omega was below 0.50 in at least one imputed dataset, that factor was considered as not having appropriate reliability and not used in the analysis. This was the case of two factors: relativity of thoughts ($\omega = 0.49$ at pretest in one imputed dataset) and insightful understanding (all omega values at pretest below 0.47). Notably, these two factors already showed the lowest indices of internal consistency in the study of Magalhães and Limpo (2022). Thus, we only used the remaining five factors. Next, we present omegas at pretest/posttest for the complete data set and, within parenthesis, for the imputed dataset representing the median: Internal Awareness = 0.61/0.61 (0.60/0.59); External Awareness = 0.78/0.80 (0.78/0.79); Acting with Awareness = 0.62/0.64 (0.58/0.65); Decentering and Nonreactivity = 0.67/0.63 (0.65/0.61); Openness to Experience = 0.80/0.78 (0.79/0.78).

Due to the removal of two factors, to examine the factorial validity of the 5-factor model at pretest and posttest, we conducted confirmatory factor analyses (CFAs) on the complete and imputed datasets. The 5-factor model revealed a very good fit for all datasets, $\chi^2(94) > 117.78$, $p < 0.05$, CFI > 0.95, RMSEA = 0.04, P (RMSEA ≤ 0.05) > 0.71.

Teacher-Rated Children's Behavior

Inattention We used the 9-item inattention subscale of the Vanderbilt Attention-Deficit Hyperactivity Disorder Diagnostic Teacher Rating Scale (Wolraich et al., 1998) validated to Portuguese by Oliveira et al. (2019). Teachers were asked to indicate how often they observed certain behaviors in a child (e.g., "Does not pay attention to details or makes careless mistakes with, for example, homework"), using a 4-point scale, ranging from 1 (*never*) to 4 (*very often*). Rather than using a dichotomic coding (presence vs. absence of symptom), we averaged teachers' responses to achieve a continuous score, with higher scores indicating greater attentional problems. McDonald's omega for complete case analysis and its median value for the five imputed datasets were above 0.93.

Emotional Lability We used the 15-item lability and negativity subscale of the Emotion Regulation Checklist (Shields & Cicchetti, 1997) validated to Portuguese by Alves and Cruz (2011). Teachers were asked to indicate how frequently a child displayed a set of behaviors, such as "Exhibits wide mood swings". Responses were given in a 4-point scale, ranging from 1 (*never*) to 4 (*almost always*), with higher scores indicating higher emotional regulation deficits. McDonald's omega for complete case analysis and its median value for the five imputed datasets were above 0.88.

Writing Performance

Handwriting Fluency It was assessed as the number of words written on a 90-s sentence-copying task, with higher scores indicating greater fluency (Cordeiro et al., 2020). Experienced research assistants scored this task. At both testing times, 30% of the tasks were rescored by a second judge. Inter-rater reliability, computed through the intraclass correlation coefficient (ICC) for single measures, was above 0.99.

Spelling Errors This was evaluated as the number of misspellings in a 16-word Portuguese dictation task (for a description, see Magalhães et al., 2020), with higher scores indicating more errors. Experienced research assistants scored the spelling tasks and a second rater scored 30% of the written materials (ICC > 0.98).

Composing Quality It was measured in an opinion essay writing task, with different prompts at pretest ("Do you think there should be more field trips?") and posttest ("Do you think it is good to have many siblings?"). The prompts were previously identified by primary-grade school teachers as appropriate in terms of difficulty and interest value, and used in past studies (Cordeiro et al., 2020; Limpo & Alves, 2013). To remove transcription biases from quality evaluations (Graham et al., 2011), the texts were typed and corrected for spelling errors. All texts were blindly double rated by two research assistants. Using a 7-point scale, ranging from 1 (*low quality*) to 7 (*high quality*), raters evaluated each opinion essay with a single value accounting for four factors: creativity, coherence, syntax, and vocabulary. Based on Cooper (1977), this holistic scale provides an overall measure of writing quality widely used in the field and sensitive to change (Cordeiro et al., 2020, 2021, 2022; Limpo & Alves, 2013). As all texts were double rated, the final score was the average across judges, with higher scores

indicating better quality. ICC for average measures was above 0.96.

Academic Achievement

We used school grades in portuguese, mathematics, and social studies, ranging between 1 (*insufficient*) and 4 (*very good*). We collected the last grades given before the interventions and the first grades given after the interventions.

Moderators

Lesson Absences Based on psychologists and teachers' reporting, we computed the number of absences in long lessons (up to 16) and in short lessons (up to 23).

Intervention-Related Knowledge We developed two similar tests tapping interventions' main contents. The number of correct answers was calculated, with greater scores indicating higher intervention-related knowledge. McDonald's omega for complete case analysis and its median value for the five imputed datasets was 0.76 and 0.75, respectively.

Perceptions of Social Validity Based on López-González et al. (2019), we created a 4-item survey asking children the extent to which the activities (a) were enjoyable, (b) helped them to be happier/healthier, (c) taught them new knowledge, and (d) should be done by all children. Children responded in a 5-point scale from 1 (*not at all*) to 5 (*totally*), with higher scores indicating higher social validity. McDonald's omega for complete case analysis and its median value for the five imputed datasets was 0.69 and 0.68, respectively.

Data Analyses

Data were analyzed using SPSS (v. 27). First, we examined the missing data pattern. As Little's test (Little, 1988) indicated that missing was not completely at random ($p < 0.001$), deletion techniques could produce biased estimates. Thus, following Enders (2010) recommendations, we use a sequential regression approach to generate five datasets.

Primary RQ: Effects of Mindfulness vs. Health Programs

To confirm the adequacy of the data for parametric procedures, we examined descriptive statistics for all dependent variables, for the original and five imputed databases. After assuring no severe deviations from the normal distribution – based on skewness and kurtosis below |3| and |10|, respectively (Kline, 2016) – a two-step strategy was followed to answer each RQ (the procedure is illustrated in Fig. S1 in Supplementary Materials).

Preliminary Analyses To increase statistical power and decrease the likelihood of Type I errors, we used multivariate analyses of (co-)variance (MANOVAs and MANCOVAs). For each set of dependent variables – dispositional mindfulness (internal awareness, external awareness, acting with awareness, decentering and nonreactivity, and openness to experience), teacher-rated children's behavior (inattention and emotional lability), writing performance (i.e., handwriting fluency, spelling errors, and composing quality) and academic achievement (portuguese, mathematics, and social studies grades) – we examined pretest differences between conditions with MANOVAs. Then, we conducted MANCOVAs to compare the effects of the MBP and HBP on the posttest scores of each set of dependent variables, controlling for the respective set of pretest scores. For all MANCOVAs, we previously examined the assumption of homogeneity of regression slopes. Violation of this assumption indicated that condition effects on posttest scores were moderated by pretest scores. When such interaction was observed, it was kept in the final MANCOVA. Because there was a tendency for the MBP to have more educated legal guardians than the HBP (see Participants section), we additionally inspected whether this variable could have influenced condition effects. As we found no evidence for that, legal guardian's educational level was left out of the main analyses.

We inspected the range of MANCOVAs results across the five imputed datasets (Manly & Wells, 2015) and only moved to univariate analyses when condition effects in the omnibus tests were consistently significant across the five imputed databases (alpha level = 0.05). Given the stringent procedures to reduce the family-wise error rate, no additional adjustments for multiple comparisons were made (Perneger, 1998).

Follow-Up Analyses of Significant MANCOVAs We examined condition effects on each dependent variable separately. Because students were nested within classes, we performed linear mixed modelling (LMM). As fixed effects, we introduced the same covariates tested in the MANCOVAs along with condition. As random effects, we introduced classroom. When there was a violation of the homogeneity of regression slopes in the MANCOVA, the respective condition x pretest score interaction was also introduced in the model. To inspect the interaction, we plotted separate regression lines by condition at ± 1 *SD* of the pretest score and conducted simple slope analyses using LMM. For all models,

we presented pooled results following Rubin's rules (Rubin, 1987).

Exploratory RQ: Moderators of Effectiveness

We first compared MBP and HBP students in terms of the moderators, by looking at the pooled results of LMM with condition as a fixed effect and classroom as a random effect. Then, for each set of dependent variables, we conducted three MANCOVAs, in which, besides condition and pretest scores, we included (1) absences in long and short lessons, (2) intervention-related knowledge, or (3) social validity, along with the respective interactions with condition. As before, univariate tests using LMM were only performed for significant effects across the five imputed datasets. Evidence of moderation was found when there were significant moderator x condition interactions, inspected by plotting separate regression lines and performing simple slope analyses using LMM.

Results

Descriptive statistics, presented in Table 1, showed that the complete-case dataset compared reasonably to the pooled dataset. The inspection of skewness and kurtosis revealed no distributional problems ($Sk < |2|$ and $Ku < |5|$).

Intervention Effects on Dispositional Mindfulness

As MANOVAs on the five imputed datasets showed inconsistent condition differences at the pretest, $\Lambda = 0.95–0.96$, $F(5, 251) = 1.63–2.92$, $p = 0.01–0.16$, $\eta_p^2 = 0.04–0.06$, follow-up tests were not performed. An inspection of the homogeneity of regression slopes revealed a Condition x Pretest Decentering and Nonreactivity interaction across the five imputed datasets, $\Lambda = 0.92–0.95$, $F(5, 241) = 2.72–4.04$, $p = 0.002–0.02$, $\eta_p^2 = 0.05–0.08$. This interaction was kept in the final MANCOVA, which showed a condition effect on posttest dispositional mindfulness, $\Lambda = 0.93–0.96$, $F(5, 245) = 3.58–2.47$, $p = 0.01–0.04$, $\eta_p^2 = 0.04–0.07$.

Since the Condition x Pretest Decentering and Nonreactivity interaction was only significant for the model with openness to experience as the dependent variable, this interaction was kept in this model and removed from all others. As displayed in Table 2, after controlling for pretest scores, pooled results revealed condition effects for internal awareness ($t = 3.08$, $p = 0.002$), external awareness ($t = 2.00$, $p = 0.05$), and decentering and nonreactivity ($t = 2.12$, $p = 0.03$). For these three facets, MBP students surpassed HBP students. Concerning openness to experience, results

Table 1 Descriptive statistics (including means adjusted for pretest scores) for all dependent variables by dataset, condition, and testing time

	Complete-case descriptive statistics												Pooled descriptive statistics (five datasets combined)									
	MBP group					HBP group							MBP group ($n = 130$)					HBP group ($n = 127$)				
	Pretest			Posttest		Pretest			Posttest				Pretest		Posttest			Pretest		Posttest		
Measures	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*M*	*M*	M_{adj}	*SE*	*M*	*M*	M_{adj}	*SE*	
Dispositional mindfulness																					
Internal awareness	118	3.51	1.28	126	4.16	1.21	115	3.56	1.23	121	3.82	1.41	3.43	4.19	4.23	0.10	3.56	3.82	3.78		
External awareness	119	4.56	1.37	128	4.76	1.31	111	4.72	1.21	120	4.65	1.27	4.47	4.78	4.85	0.10	4.73	4.65	4.57		
Acting with awareness	120	3.82	1.26	127	4.01	1.16	114	4.21	1.20	122	4.12	1.26	3.82	3.99	4.03	0.12	4.22	4.10	4.06		
Decentering and nonreactivity	120	3.52	1.33	123	3.93	1.38	111	3.43	1.50	121	3.66	1.45	3.46	3.93	3.97	0.12	3.45	3.64	3.60		
Openness to experience	119	3.00	1.48	125	2.62	1.26	112	2.93	1.38	121	2.93	1.47	3.11	2.64	2.61	0.11	2.91	2.93	2.95	0.11	
Teacher-rated children's behavior																					
Inattention	129	1.87	0.62	130	1.74	0.57	115	1.96	0.80	125	1.78	0.62	1.88	1.74	1.77	0.03	1.95	1.79	1.76		
Emotional lability	129	2.25	0.36	130	2.19	0.37	115	2.37	0.56	125	2.33	0.50	2.26	2.19	2.21	0.03	2.35	2.33	2.30		
Writing performance																					
Handwriting fluency	123	3.43	1.49	128	3.97	1.37	124	3.25	1.18	123	3.46	1.16	17.29	23.41	23.78	0.37	18.43	23.39	23.01		
Spelling errors	123	8.76	2.80	128	7.31	2.55	124	9.25	2.92	124	8.01	2.80	8.79	7.32	7.48	0.15	9.28	8.08	7.91		
Composing quality	123	17.41	4.82	128	23.41	5.29	123	18.50	5.19	124	23.23	5.75	3.42	3.98	3.95	0.10	3.22	3.44	3.45		
Academic achievement																					
Portuguese	127	2.99	0.88	130	2.93	0.82	126	2.98	0.86	124	2.95	0.76	2.98	2.93	2.94	0.04	2.98	2.93	2.92		
Mathematics	127	3.12	0.84	130	3.09	0.87	126	2.94	0.88	124	2.83	0.95	3.11	3.09	3.06	0.05	2.94	2.82	2.86		
Social Studies	127	3.17	0.78	130	3.32	0.73	126	3.43	0.67	124	3.25	0.74	3.17	3.32	3.35	0.05	3.42	3.23	3.20		

Table 2 Pooled Parameter Estimates of the Condition Effects on Dispositional Mindfulness, Handwriting Fluency, Spelling Errors, Composing Quality, and Academic Achievement Controlling for Pretest Scores

Predictors	Estimate	*SE*	*t*	*p*
Internal awareness				
Pretest internal awareness	0.17	0.08	2.19	0.03
Pretest external awareness	-0.01	0.07	-0.21	0.84
Pretest acting with awareness	0.06	0.07	0.91	0.36
Pretest decentering and nonreactivity	0.27	0.06	4.23	< 0.001
Pretest openess to experience	-0.20	0.06	-3.06	0.002
Condition	0.44	0.14	3.08	0.002
Classroom (random effect)[a]				
External awareness				
Pretest internal awareness	-0.11	0.07	-1.59	0.11
Pretest external awareness	0.46	0.07	7.03	< 0.001
Pretest acting with awareness	0.09	0.06	1.50	0.14
Pretest decentering and nonreactivity	0.15	0.06	2.32	0.02
Pretest openess to experience	-0.08	0.07	-1.12	0.27
Condition	0.28	0.14	2.00	0.05
Classroom (random effect)[a]				
Acting with awareness				
Pretest internal awareness	-0.07	0.08	-0.91	0.37
Pretest external awareness	0.01	0.07	0.23	0.82
Pretest acting with awareness	0.29	0.08	3.51	0.002
Pretest decentering and nonreactivity	0.03	0.07	0.41	0.68
Pretest openess to experience	0.15	0.06	2.35	0.02
Condition	-0.03	0.23	-0.11	0.91
Classroom (random effect)	0.08	0.06		0.19
Decentering and nonreactivity				
Pretest internal awareness	0.02	0.10	0.17	0.87
Pretest external awareness	0.04	0.08	0.47	0.64
Pretest acting with awareness	0.07	0.08	0.86	0.39
Pretest decentering and nonreactivity	0.22	0.07	3.12	0.002
Pretest openess to experience	-0.30	0.07	-4.15	< 0.001
Condition	0.38	0.18	2.12	0.03
Classroom (random effect)	0.01	0.04		0.80
Openess to experience				
Pretest internal awareness	0.06	0.09	0.73	0.47
Pretest external awareness	-0.01	0.08	-0.15	0.88
Pretest acting with awareness	0.06	0.08	0.73	0.47
Pretest decentering and nonreactivity	-0.24	0.08	-2.85	0.01
Pretest openess to experience	0.37	0.07	5.18	< 0.001
Condition	-1.11	0.44	-2.52	0.01
Condition x Pretest decentering and nonreactivity	0.23	0.12	1.94	0.05
Classroom (random effect)	0.03	0.05		0.51
Handwriting fluency				
Pretest handwriting fluency	0.68	0.06	12.12	< 0.001
Pretest spelling accuracy	-0.15	0.10	-1.54	0.12
Pretest composing quality	< 0.001	0.22	0.003	0.99
Condition	0.38	1.01	0.37	0.71
Classroom (random effect)	2.63	2.04		0.21
Spelling accuracy				
Pretest handwriting fluency	-0.02	0.02	-0.89	0.38
Pretest spelling accuracy	0.72	0.05	15.30	< 0.001
Pretest composing quality	0.01	0.10	0.14	0.89
Condition	-0.43	0.33	-1.31	0.19
Classroom (random effect)	0.22	0.16		0.18
Composing quality				

Table 2 (continued)

Predictors	Estimate	*SE*	*t*	*p*
Pretest handwriting fluency	0.04	0.02	2.28	0.02
Pretest spelling accuracy	-0.04	0.03	-1.42	0.16
Pretest composing quality	0.33	0.06	5.23	< 0.001
Condition	0.45	0.23	1.97	0.05
Classroom (random effect)	0.12	0.07		0.09
Portuguese grades				
Pretest portuguese grades	0.50	0.06	8.02	< 0.001
Pretest mathematics grades	0.17	0.06	2.92	0.004
Pretest social studies grades	0.15	0.07	2.34	0.02
Condition	0.02	0.13	0.17	0.87
Classroom (random effect)	0.05	0.02		0.04
Mathematics grades				
Pretest portuguese grades	0.17	0.06	2.69	0.01
Pretest mathematics grades	0.63	0.06	9.88	< 0.001
Pretest social studies grades	0.15	0.07	2.10	0.04
Condition	0.20	0.10	1.94	0.05
Classroom (random effect)	0.02	0.02		0.18
Social Studies grades				
Pretest portuguese grades	0.23	0.06	3.78	< 0.001
Pretest mathematics grades	0.14	0.06	2.30	0.02
Pretest social studies grades	0.35	0.07	4.87	< 0.001
Condition	0.15	0.13	1.21	0.23
Classroom (random effect)	0.04	0.02		0.06

[a]Parameters not estimated because the Hessian matrix was not positive definite

revealed an opposite pattern, with lower posttest scores in the MBP than HBP (t = -2.52, p = 0.01). Still, this effect was moderated by decentering and nonreactivity pretest scores (t = 1.94, p = 0.05). This interaction is plotted in Fig. 2 (Panel a). An inspection of that graph complemented by simple slope analyses revealed that decentering and reactivity at pretest was not associated with openness to experience at posttest in the MBP (estimate = 0.02, SE = 0.10, t = 0.18, p = 0.86). Only in the HBP, higher decentering and reactivity at pretest was associated with lower openness to experience at posttest (estimate = -0.26, SE = 0.10, t = -2.70, p = 0.001).

Intervention Effects on Teacher-Rated Children's Behavior

Across the five imputed datasets, MANOVAs showed no condition effects on teacher-rated children's behavior at the pretest, Λ = 0.98–0.99, F(2, 254) = 0.93–1.78, p = 0.17–0.49, η_p^2 = 0.01–0.06. After confirming the homogeneity of regression slopes, the MANCOVA revealed inconsistent findings, Λ = 0.97–0.98, F(2, 252) = 2.33–3.78, p = 0.02–0.10, η_p^2 = 0.01–0.03. Univariate tests were not performed.

Intervention Effects on Writing Performance

Considering the five imputed datasets, MANOVAs showed inconsistent condition effects on writing performance (i.e., handwriting fluency, spelling errors, and composing quality) at pretest, Λ = 0.97–0.95, F(3, 253) = 2.15–2.60, p = 0.05–0.10, η_p^2 = 0.02–0.03. Hence, follow-up tests were not performed. After confirming the homogeneity of regression slopes, the MANCOVA showed a condition effect across the five imputed datasets, Λ = 0.94–0.95, F(3, 250) = 4.14–5.76, p < 0.01, η_p^2 = 0.04–0.07.

As displayed in Table 2, pooled results from LMM revealed a condition effect only for composing quality (t = 1.97, p = 0.05), with MBP students producing better posttest texts at posttest than HBP students. In Table S3 of Supplementary Materials, we report the correlations between the three writing variables at the pretest and posttest by the group.

Intervention Effects on Academic Achievement

Though MANOVAs on the five imputed datasets consistently revealed condition pretest differences, Λ = 0.84–0.86, F(3, 253) = 13.60–15.34, p < 0.001, η_p^2 = 0.13–0.15, pooled LMM results showed no univariate effects (t-values < 1.51, p-values > 0.13). After assuring the homogeneity of regression slopes, the MANCOVA revealed a condition effect across the five imputed datasets, Λ = 0.95–0.97, F(3, 250) = 3.05–4.41, p = 0.005–0.03, η_p^2 = 0.03–0.05.

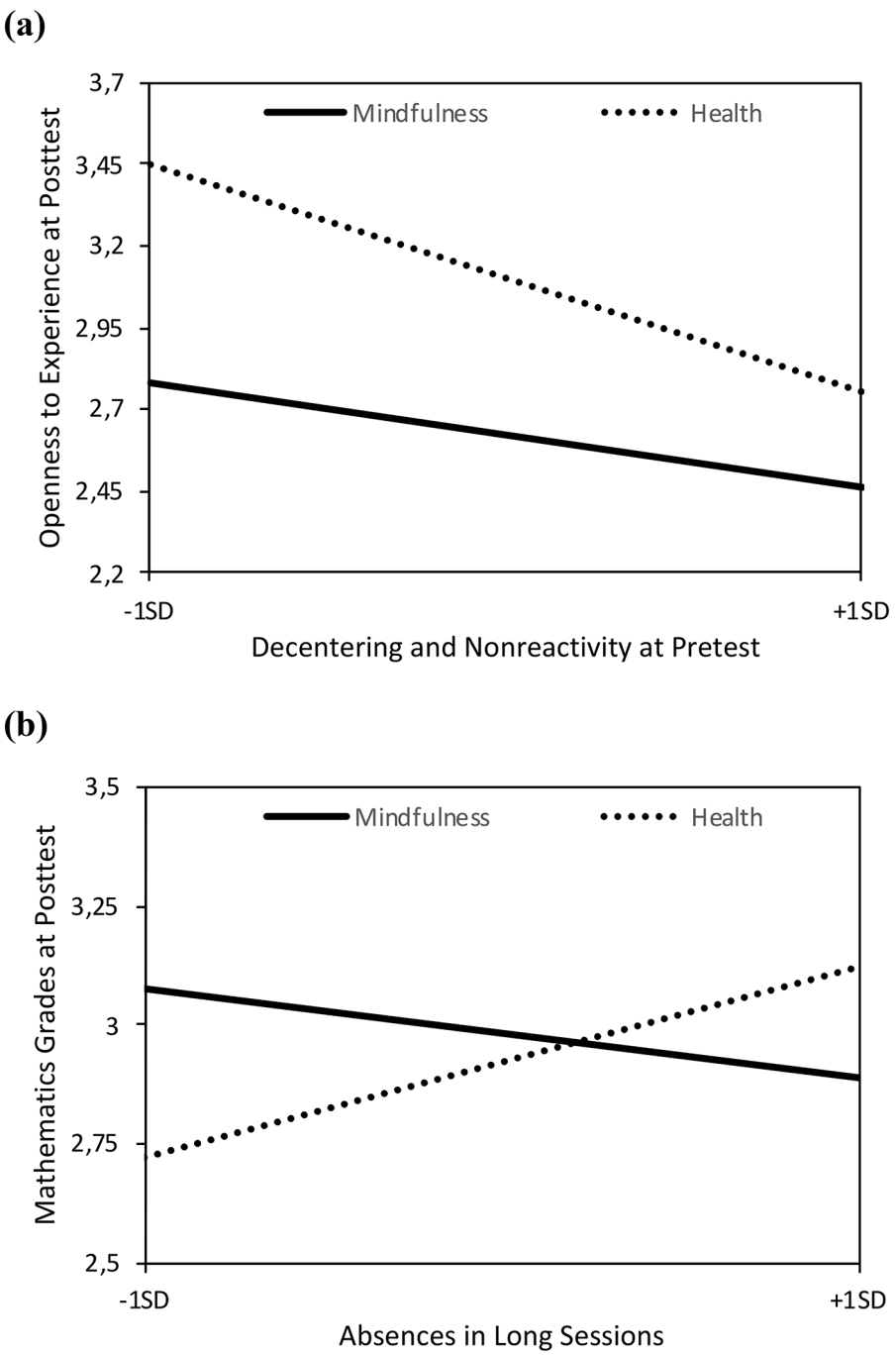

Fig. 2 Graphs of the Significant Interactions Effects Between **(a)** Decentering and Nonreactivity at Pretest and Condition on Openness to Experience at Posttest and **(b)** Absences in Long Lessons and Condition on Mathematics Grades at Posttest

As displayed in Table 2, we found a single condition effect for mathematics grades ($t = 1.94$, $p = 0.05$), with MBP students surpassing HBP students.

Moderation Effects

Complete results from all MANCOVAs across the five imputed datasets appear in Table S4 of Supplementary Materials.

Lesson Absences

In both long ($M = 1.02$, $SD = 1.69$ vs. $M = 1.76$, $SD = 2.27$) and short ($M = 1.12$, $SD = 2.11$ vs. $M = 2.69$, $SD = 3.39$) lessons, there were less absences in the HBP than in the MBP, respectively, estimate = 0.73, $SE = 0.25$, $t = 2.95$, $p = 0.004$, and estimate = 1.56, $SE = 0.35$, $t = 4.43$, $p < 0.001$. MANCOVAs only revealed an interaction effect involving absences and condition for academic achievement: better mathematics

grades were associated with less absences in short lessons (estimate = -0.06, $SE = 0.03$, t = -2.01, $p = 0.05$) and more absences in long lessons (estimate = 0.10, $SE = 0.04$, $t = 2.24$, $p = 0.03$). This latter effect varied across conditions (estimate = -0.15, $SE = 0.06$, t = -2.54, $p = 0.01$). As plotted in Fig. 2 (Panel b), mathematics grades were better in the MBP group when absences were low and in the HBP when absences were high. Simple slope analyses only showed a positive link between long lessons' absences and mathematics grades in the HBP group (estimate = 0.10, $SE = 0.04$, $t = 2.45$, $p = 0.01$).

Intervention-Related Knowledge

Pooled LMM results revealed that HBP students (pooled mean = 8.35; $SD = 2.09$) displayed more knowledge than their MBP peers (pooled mean = 6.68; $SD = 2.25$), estimate = -1.73, $SE = 0.43$, t = -4.04, $p < 0.001$. Pooled results from LMM revealed that more knowledge was associated with better grades in social studies (estimate = 0.07, $SE = 0.02$, $t = 3.04$, $p = 0.004$) and mathematics (estimate = 0.06, $SE = 0.03$, $t = 2.32$, $p = 0.03$).

Perceptions of Social Validity

Pooled LMM results showed more social validity in the HBP (pooled mean = 4.66; $SD = 0.33$) than in the MBP (pooled mean = 4.47; $SD = 0.64$), estimate = 0.20, $SE = 0.06$, $t = 3.05$, $p = 0.002$. Social validity perceptions did not interact with the condition but were associated with dispositional mindfulness, namely, internal awareness (estimate = 0.36, $SE = 0.15$, $t = 2.35$, $p = 0.02$), external awareness (estimate = 0.62, $SE = 0.15$, $t = 3.98$, $p < 0.001$), decentering and nonreactivity (estimate = 0.77, $SE = 0.17$, $t = 3.75$, $p < 0.001$), and openness to experience (estimate = -0.66, $SE = 0.19$, t = -3.49, $p = 0.002$).

Ad-Hoc Analyses

To further explore the MBPs' effects on proximal and distal outcomes, we performed additional analyses to examine whether condition effects on composing quality and mathematics grades were mediated by gains in dispositional mindfulness. However, using the PROCESS macro for SPSS version 3.5 (Hayes, 2018), we found no consistent evidence of mediation across the five imputed datasets.

Discussion

This quasi-experimental study examined MBPs' effects on fourth graders' dispositional mindfulness and behavior (i.e., inattention and emotional lability), as well as writing performance (i.e., handwriting fluency, spelling errors, and composing quality) and academic achievement. We additionally inspected whether these effects were moderated by absences, knowledge acquisition, and social validity. In general, compared to the control condition, the MBP improved internal and external awareness, and decentering and nonreactivity, as well as composing quality and mathematics grades. There was no evidence of moderation effects. These findings are discussed next.

In line with past evidence with older populations (Hafeman et al., 2020; Quaglia et al., 2016), our findings revealed that our MBP improved the mindfulness facets of internal and external awareness as well as decentering and nonreactivity. It seems that the MBP enhanced children's emotional and environmental awareness, along with their ability to step back from difficult emotions and thoughts. Although these results should be carefully read, given the moderate reliability of the internal awareness factor, they replicate previous evidence showing that MBPs are an effective means of improving dispositional mindfulness (Hafeman et al., 2020; Quaglia et al., 2016). This is an encouraging finding for at least two reasons. First, there is evidence linking dispositional mindfulness with several indicators of mental health (Tomlinson et al., 2018). Second, dispositional mindfulness, particularly its decentering facet, was found to be a protective factor against psychological distress during COVID-19 (Kock et al., 2021). As our study was conducted during this pandemic, the enhanced dispositional mindfulness may have helped our participants deal with the stress and anxiety associated with it (Sun et al., 2022). Yet, more research is needed to support and extend these results.

However, there was an unexpected finding involving the mindfulness facet of openness to experience, whose posttest scores were lower in the MBP than HBP group. Despite appearing counterintuitive, this finding is aligned with a study showing that openness to experience was negatively associated with other mindfulness facets, positive feelings, and quality of life (Magalhães & Limpo, 2022). As suggested by Magalhães and Limpo (2022), this may be explained by a misinterpretation of the items, since ten-year-olds may still struggle with abstract concepts (Tyler, 2020), as those underlying openness to experience. Future research focused on how children interpret this factor seems warranted.

Although the goals of MBPs target attention and emotion regulation (Semple et al., 2010), we did not find condition effects on these variables. These findings do not agree with some studies (Magalhães et al., 2022), but are in line with a meta-analysis (Zenner et al., 2014). The lack of effects may be due to three reasons. First, some activities might have been more cognitively demanding than anticipated. Past evidence suggested that MBPs may work better among children with higher cognitive functioning (Cordeiro et

al.,2022). Second, the number of sessions may have been insufficient to reduce inattention and emotional lability, as already claimed by Campbell et al. (2019), who found no effects on emotion regulation after a 6-week MBP. Third, the MBP may have worked differently during the pandemic. Another study conducted during this period found no attentional benefits after an MBP (Malboeuf-Hurtubise et al., 2021). There is evidence that factors associated with the pandemic context, such as anxiety due to the public health crisis, economic insecurity, and political instability, may affect participants' responses to treatments (Peyton et al., 2022). Moreover, the pandemic also led to changes in the implementation of research protocols (Perlis et al., 2021), though with minimal impact.

Partially confirming our hypotheses, we found that compared to the control condition, the MBP improved composing quality, but there were no effects on handwriting and spelling. There is accumulating evidence on the lack of effects of MBPs on spelling (Bakosh et al., 2018; Cordeiro et al., 2021; Magalhães et al., 2022). This result may be due to the complex nature of this ability, which requires explicit instruction to be promoted (Graham, 2000). As for handwriting fluency, our findings contrast with those of Cordeiro et al. (2021), likely due to samples' grades (Grade 4 vs. 3). It may be more difficult for non-specific interventions to increase this skill in Grade 4, when it is more developed. While there was no effect on these processes, there was on composing quality, which depends upon both writing-specific skills as well as general skills, such as executive functions (Limpo & Olive, 2021). The latter are critical to write good texts and have been positively impacted by MBPs (Dunning et al., 2019).

Regarding academic achievement, the MBP resulted in better grades only in mathematics, as reported by Bakosh et al. (2018). The developmental socio-cognitive neuroscience perspective of Zelazo and Lyons (2012), presented in the introduction, may help to explain the added value of MBPs in mathematics. On the one hand, mathematics performance has been associated with working memory components (Friso-van den Bos et al., 2013), which appear to be enhanced by MBPs (Mrazek et al., 2013). On the other hand, results from previous studies indicated that mindfulness exercises may reduce child anxiety (Crowley et al., 2017), which is especially prominent in this subject (Luttenberger et al., 2018). Though reasonable, these explanations were not tested in this study and should be examined in future studies, for example, by testing the mediating role of working memory and anxiety in the link between MBPs and mathematics grades.

Contrary to our expectations, lesson absences, intervention-related knowledge, and social validity did not moderate the effects of the MBP. Even so, these results should be interpreted with caution, due to ceiling/floor effects. Future studies should be conducted with greater variability in these characteristics. Yet, our moderation analyses revealed three findings worthy of discussion. First, more absences in long sessions were associated with better mathematics grades in the HBP, which contrasts with previous evidence (Scott-Hamilton & Schutte, 2016). We could not find relevant information to advance a plausible explanation to this result, which can be a study's artifact or the effect of a confounding variable (e.g., mathematics support). Second, regardless of the program, those who acquired more knowledge achieved better mathematic grades. Though not confirming the proposal of Birrer et al. (2012), these results suggest that the acquisition of intervention-related knowledge may magnify the impact of any intervention on school grades. Alternatively, this finding may also be attributed to a common underlying cause not here measured, such as higher learning abilities, reasoning skills, or school commitment. Third, higher social validity was associated with greater dispositional mindfulness, suggesting that valuing a program may be associated with mindfulness traits development. These results should however be read carefully as social validity questions may be prone to social desirability.

Limitations and Future Research

Our findings should be interpreted considering the limitations that may guide future research. First, the study was implemented during the COVID-19 pandemic, which may have influenced participants' response to treatment and resulted in weaker effects (Peyton et al., 2022). Testing the current MBP outside a pandemic context seems needed. Second, this study included self- and teacher-reported measures that may have led to response bias. Specifically, we used researcher-constructed questionnaires to measure intervention-related knowledge and social validity. Moreover, the same schoolteachers ran the 5-min short lessons and rated children's behavior. Additional behavior observations and performance-based measures may be considered in the future, along with the use of blinded raters to participants' conditions. Third, composing quality was assessed in opinion essay tasks, limiting generalization to other genres. Replication of our findings in other genres is warranted. Fourth, although the two programs were equivalent in key features, we cannot objectively tell if the MBP and HBP differed in terms of higher-order thinking and engagement. It would be relevant to examine whether mindfulness training involves cognitive and motivational demands equivalent to comparison training. Fifth, even though psychologists and teachers were instructed to be aware of any discomfort manifested by children during meditations, we did not systematically monitor the potential adverse effects of

meditation. Past research testing MBPs already identified meditation-induced side effects, such as hyperarousal symptoms (e.g., anxiety and insomnia) and, albeit less frequently, dissociation symptoms (e.g., emotional blunting, derealization, and self-disturbance (Britton et al., 2021). Monitoring these effects seems an important goal for future research, which will maximize the safety of MBPs. Sixth, Bonferroni adjustments were not applied since introducing several procedures to control Type I errors would increase the likelihood of Type II errors. Caution is needed when interpreting our findings about the variables that successfully changed in result of the MBP. Finally, given the pandemic lockdown, we neither conducted a follow-up assessment nor collected feedback from teachers and psychologists. In the future, it would be useful to inspect the program's maintenance effects and stakeholders' perceptions of acceptability.

Overcoming several limitations in the field, this study compared the effects of an MBP with an active control group in a non-clinical setting. We found no evidence of moderator effects, but we observed MBP-related improvements on some mindfulness traits, composing quality, and mathematics grades. When reading these findings, it should be kept in mind the high level of treatment fidelity. We believe this could be explained by the training provided, which included weekly monitoring sessions and frequent communications through digital means along with the cooperation of the school staff. Though more research is needed to understand the mechanisms underlying these effects, our findings support the inclusion of MBPs to complement the primary school curriculum.

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Author Contribution TL: designed the study, co-developed the interventions, supervised the study's implementation. TL and AIV: wrote the manuscript. SM, RRoc, and CC: implemented the study, including data collection and coding. RRod, AC, RN, JJ, PC and MP participated on the study design and developed audio materials. All authors reviewed and approved the final version of the manuscript. SLC advised on the study design and revised the manuscript.

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Data Availability All data are available at the Open Science Framework (https://osf.io/f8dpx/?view_only=b4ec91b6a32c4f3181d59316d79f547a).

Declarations

Conflict of interest The authors have no known conflicts of interest to disclose.

Ethics Approval This research involved underaged human participants and was approved by the ethical committee of the University of Porto.

Informed Consent Oral assent from participating children and written informed consent from their legal guardians was gathered.

Preregistration This study is not pre-registered.

Use of Artificial Intelligence No Artificial Intelligence tools were used

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