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An empirical study to evaluate the impact of mindfulness on helpdesk employees

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ABSTRACT

Purpose: Mindfulness is a meditation technique whose main goal involves maintaining a calm mind and training attention by focusing only on a single thing (the support) at a time; this support is usually the practitioner's breathing. The practice of mindfulness aims to improve concentration and attention, which has proven useful in knowledge-intensive and stressful work environments like technological companies. This article aims to find empirical evidence on the positive effect of the practice of mindfulness on a sample of 56 helpdesk employees working for a consulting and information technology company (Accenture) with respect to: i) their attention awareness; ii) a set of key performance indicators (KPIs); and iii) the perceived benefits of mindfulness. **Method**: Of the 56 recruited employees, 29 worked as managers, and 27 worked as agents answering phone calls to solve software issues of the main information system of the Andalusian Health Service, a public organization with more than 115,000 employees. Mindfulness (the treatment) was applied to 26 subjects, while the other 30 subjects were the control group. For all subjects, their attention awareness was measured using the MAAS scale. **Results**: Both helpdesk managers and agents significantly improved their attention awareness with respect to the control group. Regarding organizational KPIs, in general, no evidence of significant differences between groups was detected, apart from the fact that the number of phone calls answered was significantly lower in the mindfulness group, probably due to a longer call duration caused by a deliberate better attention to the customer, but without degrading any other KPI. With respect to the perceived benefits of the treatment, the questionnaires show relevant improvements perceived by most employees after practicing mindfulness.**Conclusions**: We confirm that mindfulness improves attention awareness and benefits the working and personal life of helpdesk employees. However, further research is needed to identify a clear impact on productivity.

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1. Introduction

The interest in the influence of human-centered skills on the smooth of companies has grown in the last years. Empathy, self-control, flexibility and mood are well known as positive factors [1–3], while stress, burnout, and lack of attention have a negative impact on the work performed [4,5]. Focusing on stressful environments, people usually experience a *monkey mind*, in which their minds jump from one thought to another, like a monkey from branch to branch, in an anxious and confused incessantly moving [6]. This behaviour is inherent to the human mind, but it makes difficult to focus our attention on the current task [7].

Mindfulness meditation[1] is a meditation technique that constitutes an option to improve such non-attentional behaviour. A session of formal mindfulness consists of focusing attention for a period of time on a specific support, usually breathing [8]. The goal of mindfulness is to transfer the state of awareness achieved during its practice to our daily life [9]. It should reduce *monkey mind* and improve not only the chances of focusing on the task at hand but also mental clarity, thus enhancing problem-solving capabilities [10]. After a period of continuous practice, the brain becomes more attentive [11], calmer [7], more concentrated [12], less ruminative [13] and, as confirmed by a meta-analysis looking at 20 empirical studies [14], it reduces the symptoms associated with stress.

Mindfulness has proven useful in knowledge-intensive and stressful work environments with high attention demands and has been widely adopted by large technology companies, such as Google, SAP, Intel and Goldman Sachs, to improve the well-being of their employees [15,5,16,17]. Some academic initiatives have also emerged to use mindfulness as a learning tool for students across a wide variety of age and education levels [18], including higher education [19].

In order to look for empirical evidences of the benefits of mindfulness in academia, we started, in 2013, a family of experiments designed to study the effects of its practice on the performance of undergraduate Software Engineering students. These controlled experiments were conducted over three consecutive academic years on second-year students at the University of Seville. The meta-analysis of the family of experiments [20–22] shows that students who exercised mindfulness daily for six weeks were more effective and efficient (at conceptual modelling) than students who did not practice mindfulness meditation.

Following up our results in academia, in an attempt to further generalize these outcomes, as Wohlin et al. recommended [23], we conducted a similar empirical study at the Seville (Spain) branch of Accenture, a widely known consulting company specialized in information technology. Our study was carried out with a team of highly skilled technical helpdesk whose job is to answer (mostly telephone) queries related with a software system in the health service department. Help desk agents have reported they are often involved in stressful situations that require strong concentration and self-control to solve the issues reported by the usually numerous, sometimes upset, end users of the complex software system at hand.

In this stressful environment, Accenture's management team wanted to improve the well-being of its employees. We believed that employee stress levels would decrease if they were to take advantage of the benefits mindfulness practice (like attention awareness,[2] calm and mental clarity) [25–27]. Besides, since previous evidence shows that emotional intelligence capabilities help cope with stress [28], we think mindfulness could lead Accenture's professionals to provide a better service for their customers.

Encouraged by our experience with students and by movements within other universities and companies, our proposal to Accenture was to promote the daily practice of mindfulness (for six weeks) in order to find empirical evidence on the positive impact of the practice of mindfulness not only on agents' attention awareness and perceived well-being, but also its effect on their job performance.

Considering all this, the research question of the present work was:

> *Does the practice of mindfulness have an impact on Accenture helpdesk employees' attention awareness levels, perceived well-being and performance?*

In order to answer this question, we conducted an empirical study with 56 subjects recruited from the Accenture help desk in Seville to analyze: i) attention awareness; ii) performance; and iii) perceived benefits of mindfulness. Of these, 29 professionals had a job in management, whereas the other 27 are agents that answer phone calls about complex technical issues of the main information system of the Andalusian Health Service, a public organization with more than 115,000 employees. Analysing the behaviour of the 56 subjects, we observed that the practice of mindfulness for six weeks significantly increased participants' attention awareness and improves their perceived benefits, as we had hypothesized.

For the 27 subjects with technical roles, we studied the impact of mindfulness on their performance, which was measured according to a set of KPIs provided by Accenture such as *number of answered phone calls, percentage of resting time, percentage of waiting for calls time, number of errors, and percentage of problems solved*. These metrics were extracted from a full set of KPIs that Accenture defined to comprehensively track the productivity of its employees.

Regarding organizational KPIs, in general, no evidence of significant differences between groups was detected, apart from the fact that the number of phone calls answered was significantly lower in the mindfulness group, probably due to a

[1] For the sake of brevity, we will use the term *mindfulness* to refer to *mindfulness meditation*.

[2] The ability to pay attention nonjudgmentally to what is happening at the present moment and stay calmed and focused [24].

longer call duration caused by a deliberate better attention to the customer, but without degrading any other KPI. All in all, our results are consistent with previous studies on mindfulness, where attention awareness improves with the practice of mindfulness, thus decreasing stress. However, more empirical studies are needed to understand its impact on performance [5,29,30].

The remainder of the article is organized as follows. Section 2 describes background research to provide, on one hand a brief introduction to helpdesk management and its performance and, on the other hand, a better understanding of the practice of mindfulness and its personal –from the point of view of neuroscience– and professional benefits. Section 3 describes related work and highlights the originality of our research within this context. Section 4 describes the experimental planning and design. Section 5 explains statistical and descriptive results. Section 6 discusses possible justifications of the results. Finally, Section 7 discusses conclusions and future work.

2. Background

2.1. Measuring helpdesk performance

With the increasing complexity of information systems, helpdesks have proliferated as a mechanism to help the end-user solve problems encountered in the use of information technologies or a particular information system [31]. The end-user reports an incident (a.k.a. ticket) describing the problem encountered, via a phone call or web application. After the explanation of the incident, a dedicated agent guides them through the resolution of the problem.

Nowadays, to measure the performance of a helpdesk, organizations usually use KPIs calculated from the work performed by the agents according to efficiency and productivity metrics —as Accenture did— such as number of tickets, ratio of closed tickets, number of events to resolve a ticket, number of tickets solved by agent in a period of time, average of duration of a ticket by agent [32,33].

On the other hand, several strategies have emerged to further study helpdesk operation and increase its performance, i.e. i) optimizing ticket allocation among agents according to their experience [32]; ii) relying on collaborative systems, in which agents share their knowledge with each other [34]; iii) analyzing customer satisfaction through surveys as suggests [35]; iv) studying the influence of human-centered skills as is the case of the current study [36].

2.2. Neural benefits of mindfulness meditation

A basic recommendation for practising mindfulness meditation is to sit motionless with your eyes closed and in silence for a period of time, paying attention to a specific *anchor* [37]. Usually, this anchor is breathing, since it is an essential part of being alive [8]. During a mindfulness meditation session, a person focuses her attention on her breathing, putting away anything that interferes with her focus or draws attention away from the anchor. Thoughts, physical sensations or emotions that come to mind must be set aside and her attention brought back to the anchor [7].

Neuroscience has explained that mindfulness produces changes in brain activity. On one side, our prefrontal cortex, the part of the brain responsible for problem-solving, has evolved over time to solve physical problems like creating tools or weapons [7]. However, in today's world, we face a wide range of problems, including abstract and social ones, like reaching a consensus with others. Unfortunately, when the prefrontal cortex becomes overactive, we undergo a *monkey mind* state of mind –it involves an enhance of ruminations and digressions– which can prevent us from seeing things clearly and solving problems effectively [38]. This overactivity is increased not only by our constant connection to technology, the never-ending interruptions from our devices, but also internal interruptions such as thoughts or emotions. Nevertheless, continued practice of mindfulness meditation reduces the overactivity of the prefrontal cortex and increases the activity of other areas of the brain that are active when concrete tasks are performed for specific tasks [39]. So, by practising mindfulness, we can improve our problem-solving abilities and achieve a clearer perspective on reality, even with constant interruptions.

On the other side, the vagus nerve is a crucial part of the parasympathetic nervous system, and toning it is vital for recovering from stress. When the body experiences stress, adrenaline is released, who travels to the brain via the vagus nerve and is stored in memory. As commented in Penzenstadler *et al.* [40], restoring the nervous system, which can be achieved through certain breathing practices, such as mindfulness meditation, helps people respond to stress using attention and awareness. Furthermore, functional changes in brain networks related to attention, affective processing and awareness have been observed after two weeks of mindfulness meditation practice. Ten 30–minute sessions of brief mental training were administered during two–weeks [41].

Apart from cognitive and affective effects in two weeks at the neural level [41], several empirical studies have reported the benefits of practising mindfulness in long terms, namely i) improvement of sustained attention [42]; ii) increased working memory capacity [12]; iii) ability to deal with stress [43] by reducing mind wandering; or iv) more positive emotional tone [44], which may be relevant to day-to-day workplace climate [5].

As a result, we hypothesize that Accenture employees' daily mindfulness practice can reduce stress and enhance the problem-solving ability of helpdesk employees, thereby improving their productivity and well-being.

2.3. Mindfulness at the workplace

Considering the reported benefits above, mindfulness has entered the mainstream media, getting the attention of schools, several universities [19,45], psychologists' practices [10] and companies from the health [46], IT [47] or military [48] sectors.

Particularly, in IT, mindfulness started to be applied in Google, in 2007 when one of Google's earliest engineers, Chade-Meng Tan, gathered a team of leading experts developing a mindfulness based program as an internal course for fellow Google employees. The course used to have a six–month wait list and had been taken by more than 1,500 employees. Participants of the program have reported being calmer, more patient, and better able to listen. They also say the program helped them better handle stress and defuse emotions [49]. Following the same trends, several companies of Sillicon Valley began to promote the practise of mindfulness amongs their employees [47]. Companies such as INTEL, IBM or Deloitte also report that well–being achieved as a result of mindfulness practice is returned to the organization in the form of increased awareness, motivation, engagement, concentration and emotional intelligence [16].

The approach to introducing mindfulness in organizations ranges from allowing employees to spend time on mindfulness at the company's own offices to organizing company-funded training programmes to acquaint employees with the practice of meditation [50]. For instance, the program Search Inside Yourself (SIY) —born at Google after the Chade-Meng Tan's initiative— consists of a two-day intensive meeting in which explanations and talks alternate with group meditation sessions and cultivate several of the activation mechanisms of mindfulness, i.e., attention, active listening, self-awareness, etc. For eight weeks after the course, practitioners receive a daily reminder and a mindfulness audio-guide to continue daily practice, as well as supplementary material to expand their knowledge and engagement with the practice [50].

In summary, the practise of mindfulness at the workplace has a positive impact in well–being, job-satisfaction, work-related stress and interpersonal relationships [16,51,5,52]. However, a recent meta–analysis [53] reveals that more research is needed to investigate potential benefits on engagement and productivity, the results of which were limited by the low number of primary studies that additionally reveal a low effect sizes. As a consequence, further research is recommended.

3. Related work

There are several contexts where mindfulness has been previously applied. The work of Kersemaekers et al. [52] has evaluated the feasibility and effectiveness of mindfulness in the workplace in terms of burnout, psychological well-being, organizational and team climate, and performance. The study is conducted in four companies: a European skin care products company; a global automotive supplier; a European space research and technology organization, and a global pharmaceutical company. Similarly, Karlin's work [54] has evaluated the application of mindfulness in two companies: a national vision insurance company; and a Pennsylvania pharmacy benefits manager. Both Kersemaekers et al. and Karlin agree with the results that the practice of mindfulness can help employees reduce stress and be more effective and focused. Another context in which mindfulness has been evaluated is teaching. The work of Hwang et al. [55] has conducted a systematic literature review to report on the developments and implementations of mindfulness-based intervention research for in-service teachers. This review highlighted in-service teachers' experiences of learning and practicing mindfulness and provided potential explanations for the effects of mindfulness-based interventions. Another context of the use of mindfulness in healthcare. Gilmartin et al. [56] have conducted a systematic review of the literature on the effects of brief mindfulness interventions on providers' well–being and behaviour. Studies that tested a brief mindfulness intervention with hospital providers and measured changes in well-being (e.g., stress) or behaviour (e.g., tasks of attention or reduction of clinical or diagnostic errors) were selected for the study. The review concludes that larger studies are needed to assess the impact on clinical care.

Apart from the aforementioned studies, we have reviewed work related to mindfulness in the context of software engineering. We conducted a targeted literature review (TLR), a non–systematic, in–depth, and informative literature review aimed at keeping only the significant references to maximize rigorousness, while minimizing selection bias. The goal of searching papers that validate mindfulness in the context of software engineering is translated into the following search string: "mindfulness" AND ("experiment" OR "validation") AND LIMIT-TO (SUBJAREA, "COMP"). The search was conducted using the Scopus search engine, which has access to most common digital repositories of papers. The **inclusion criteria** are: (IC1) papers that deal with the practice of mindfulness in any context related to software engineering; (IC2) papers that use software engineering as a tool to improve mindfulness. The **exclusion criteria** are: (EC1) papers that do not validate the approach; (EC2) papers that deal with mindfulness as a philosophical term but do not apply the meditation sessions; (EC3) papers that are not related to any field of software engineering. Below, we describe the papers that satisfy our parameters. This search was conducted in February 2022.

Table 1 shows the jobs found through such TLR. The first group of papers that we found in the literature champion the use of virtual reality to apply mindfulness. One of these papers is the written by Best et al. [57], which conducted a systematic review to look for virtual reality experiences to apply mindfulness. Results show that virtual reality experiences may contain valuable content that could support mental health therapy. As main limitation, how the virtual reality can be applied in real systems have not been assessed. The work of Costa et al. [58] proposes the use of nature in virtual reality themes to create an idealized space for meditation. This approach was evaluated using 21 subjects, and the results revealed that perceived restorativeness is positive and correlated with the quality of the meditation session. The main limitation of this evaluation is that virtual reality was applied in only a few environments, which reduces the generalizability of

Table 1
Summary of empirical studies about mindfulness in any context related to software engineering.

Author	Scope	Goal	Results	Limitations
Best et al.	Virtual reality to apply mindfulness	A systematic review of virtual reality application in mental health	Virtual reality support mental health therapy	Real world application of virtual reality has not been assessed
Costa et al.	Virtual reality to optimize environments for meditation	Perception of restorativeness and session quality was positive	Few environments analysed	
Damen and Spek		Using virtual reality to support starting with mindfulness	No significant positive effects were found	Very short experiment, 10 minutes
Min et al.		Analyze the effect of calm and disturbing in mindfulness	Calm is helpful to self-regulate lower heart rate. Disturbing on the contrary	Metris are based on earth and blood pressure
García and Plaza		Propose an agent-based simulator of emotions in mindfulness	Simulated outcomes are similar to the real ones	Not all emotions can be simulated
Yildirim and O'Grady		Enhance the level of state mindfulness through virtual reality	More robust immersive mindfulness intervention after using virtual reality	There is no metric to measure engagement level
Denecke et al.	Support tool for mindfulness	A chatbot to support mentally ill people suggesting mindfulness activities	Efficiency, perspicuity and attractiveness are positive using the chatbot	Chatbot does not cover all relevant emotions
Niksirat et al.		A framework for interactive mobile applications to self-regulate attention	Positive results using the framework in non-standard environments	Metrics are based on electroencephalography and heart rate
Roquet and Sas		Expert evaluation study of applications for mindfulness	Proposal of design implications and guidelines for new applications	The evaluation relies on a single expert
Sliwinski et al.		Modifications of an application for training mindfulness	Micro-tasks fit current schedules and engage users	Metrics depend on non-standard questionnaires
Zhu et al.		A classification of mindfulness application into 4 levels	The levels help in planning the design of mindfulness applications	Evaluation through interviews, no questionnaires or objective metrics
Morales et al.	Mindfulness in software development	Mindfulness application before learning programming concepts	Higher improvement in programming scores, higher satisfaction and motivation	The subjects where students between 10 and 12 years old. The experiment focus on learning programming, not in programming
Heijer et al.		Mindfulness in agile software development teams	Better perceived effectiveness, decision-making and improved listening	Non-standard questionnaires used in the validation

results. Other researchers as Damen and van der Spek [59] propose the application of virtual reality to support mindfulness for beginners. To do this, they defined three virtual attention exercises based on expert meetings with a therapist. The approach was validated on 30 subjects. Results show no positive effects on the use of virtual reality. There is no appreciable novelty effect from visual reality. This result may be due to the short period of time spent applying virtual reality, limited to only 10 minutes. Other researchers [60] in this field conducted an experiment with 25 subjects based on polarizing content type through virtual reality. The experiment focused on comparing calm versus disturbing. The results showed that calm was helpful for self-regulating heart rate and blood pressure, whereas disturbing did the opposite. The main limitation of this research is that the experiment only analyses blood pressure and heart rate. There are no analyses of attention awareness. Garcia and Plaza [61] proposed an agent-based simulator of emotions in mindfulness. This way, instructors can define different mindfulness programmes and simulate their repercussions on the emotions of a group of practitioners with certain features. The simulator was validated on 40 subjects. The results show that simulated and real outcomes are similar when establishing the same input circumstances. The main limitation of this approach is that not all emotions can be simulated. Yildirim and O'Grady [62] applied virtual reality to induce a greater level of mindfulness when compared to an audio-based intervention. They recruited 48 subjects for the validation, and results showed that the use of virtual reality induces a greater state of mindfulness. The main limitation of this validation is that there are no metrics to measure the engagement level. All these papers share the same limitation: evaluations are focused on the virtual reality application instead of in the mindfulness meditation. So, results cannot be generalized to the general practice of mindfulness.

As a result of our literature search, we found another group of papers that proposed tools to support mindfulness. For example, Denecke et al. [63] proposed a chatbot that implements methods from cognitive behaviour therapy to support mentally ill people in regulating emotions. Depending on the emotion, some mindfulness exercises are suggested. The chatbot was validated on 21 subjects, and results showed that efficiency, perspicuity and attractiveness are good when using the chatbot. The main limitation of this approach is that the chatbot does not cover all relevant emotions. Therefore, there are situations for which there are no mindfulness recommendations. Niksirat et al. [64] proposed a framework for developing mobile applications to self-regulate attention according to abilities and conditions. The developed applications are suitable for mindfulness practice. The framework was validated using 18 subjects. Results indicated that framework use is positive, and it can be comfortably used in non-standard environments. The main limitation of this research is that metrics are based on electroencephalography and heart rate, and there is no study of attention awareness. Roquet and Sas [65] evaluated the 16 most popular iPhone mindfulness applications to look for limitations. Based on the results of this evaluation, they defined a list of implications for designing mindfulness applications, as well as guidelines for evaluating such applications. The main limitation of this validation is that it was conducted by a single expert. Sliwinski et al. [66] improved a mindfulness training application. It was evaluated on 20 subjects. Results showed that micro-tasks using the modified version of the application require schedules and they also engage users through playful audio-visual feedback. The main limitation of the validation is that metrics are not based on standard questionnaires, and thus the conclusions may be biased. Zhu et al. [67] proposed a classification of mindfulness applications into four levels. These structured levels include specified design qualities based on specific examples of existing mindfulness applications, as well as fictional design examples. The results of a validation with 10 subjects yielded that the division is useful for discussing and planning the design of mindfulness applications and digital artefacts. The main limitation of this validation is that it is based on interviews, with no questionnaires or other objective metrics. The main limitations of all these works are that all these tools that apply mindfulness are evaluated by experts or with subjective metrics. Moreover, assessments focus on the tools to help in the mindfulness application, not in the mindfulness meditation.

Other research deals with the application of mindfulness for software development. One example proposes applying mindfulness before learning programming [68]. They applied mindfulness to 137 subjects before teaching them programming. The target was to reduce distractions and stress to keep the focus on learning programming. The results showed that there was a bigger improvement in programming scores, satisfaction and motivation of subjects with mindfulness. One of the limitations of this validation is that the subjects are 10- to 12-year-old students. Another limitation is that mindfulness was applied to learning programming, not to real programming. Therefore, the results cannot be generalized to contexts other than teaching. Heijer et al. [69] conducted a similar validation within a real development team. They analysed the impact of applying mindfulness to software development teams based on agile methodologies. Mindfulness was applied for three minutes in the stand–up meetings for two months. A total of 61 subjects from eight different companies participated in the experiment. Findings indicated a positive impact on perceived effectiveness, decision–making and improved listening in the groups where mindfulness was applied. One limitation of that experiment is that they used non–standard questionnaires.

These works share the same context: software development teams; but there is a lack of how mindfulness can affect the technical service of helpdesk employees once the software has been developed.

In sum, we can highlight that little research dealing with mindfulness has been conducted in the software engineering context [68,69]. These underscores the originality of our approach, which aims to evaluate mindfulness in a team that solves technical problems over the phone. Another idea that we can extract from the related work is that the combination of virtual reality and mindfulness helps to relax the mind, which is required to apply mindfulness. This was a finding of research like [58], [59] and [62]. There are other tools, apart from virtual reality, that support mindfulness activities, like chatbots [63] or mobile applications [65,66]. However, no previous research has set out to analyse the results of applying mindfulness in a company that solves technical issues over the phone. Note also that most of the related work on this topic

recruited students. Only a few papers analysed mindfulness application with experts or real workers ([58], [63], [61], [69], [60], [66], [67]).

4. Experimental planning

In this section, we describe the experimental process of our study according to Wohlin's guidelines [23] below.

4.1. Goals

The goal definition of the experiment using the GQM template [70] is:

Analyse *the practice of mindfulness*
for the purpose of *evaluating its effects*
with respect to *attention awareness, perceived benefits of mindfulness and performance of professionals*
from the point of view of *the experimenters and company managers*
in the context of *Accenture, a software engineering company providing technological support.*

4.2. Research questions and hypotheses

We aim to analyse the effects of mindfulness using response variables related to employee attention awareness, performance and perceived benefits of mindfulness. Following [5], we measure stress based on the attention awareness level measured using MAAS scale [71]. Performance is measured based on a set of KPIs that Accenture collects to follow-up employee performance. Finally, perceived benefits of mindfulness is measured using an *ad–hoc* questionnaire and some open questions. Considering all this, the research questions were:

RQ_1 Does the practice of mindfulness have an impact on Accenture helpdesk agents' attention awareness? This *RQ* leads to $H_{0,1}$ enunciated below which is analysed by statistical tests.
RQ_2 Does the practice of mindfulness have an impact on Accenture helpdesk agents' performance? This *RQ* leads to the set of hypotheses $H_{0,2-6}$ enunciated below which are also analysed by statistical tests.
RQ_3 Have agents experienced any improvements in their overall well-being as a result of practicing mindfulness? This *RQ* is being analyzed through both descriptive analysis and narrative synthesis.

According to the above *RQs*, we defined one null hypothesis for attention awareness and another for each KPI of Accenture employees, with the aim to analyse them in our experiment.

$H_{0,1}$: When applying mindfulness, there is no difference in attention awareness.
$H_{0,2}$: When applying mindfulness, there is no difference in the number of answered phone calls.
$H_{0,3}$: When applying mindfulness, there is no difference in the time that the worker is resting (a short break within the working period).
$H_{0,4}$: When applying mindfulness, there is no difference in the time that the worker is waiting to answer new phone calls. This waiting time refers to the time that the worker is doing other tasks different from answering phone calls (for example, report writing). Note that answering phone calls is the most priority task, so employees must answer the phone call once the telephone rings, discarding other possible tasks.
$H_{0,5}$: When applying mindfulness, there is no difference in the number of errors in answered phone calls.
$H_{0,6}$: When applying mindfulness, there is no difference in the settlement of issues raised in each phone call.

4.3. Factors, response variables and metrics

The independent variable or factor whose effect on the response variables we aim to understand is **Method**. This factor has two levels: *mindfulness* (the treatment) and *none* (the control against which the treatment is compared).

The treatment applied to the experimental group is the attendance of a six–week mindfulness workshop on Accenture premises. The workshop was held at 7.00 am four days a week, before agents started their workday. The mindfulness workshop consisted of a 15–minute guided mindfulness practice session, following the prescription described at the beginning of Section 2.3 and detailed in Section 4.5 (Step 6).

Since we aimed to test if there were differences in job performance when mindfulness was exercised, we included a second factor: **Time**. This factor represents the moment in time when the respective response variables were measured for the subjects. Accordingly, this factor has two levels: *Pre* (before) and *Post* (after) so that we can compare the subjects before and after applying mindfulness.

In order to assure that random variability related to small differences from day to day does not affect the results, we gathered data for four weeks before applying mindfulness (from week 1 to 4 in Fig. 1), for three weeks while applying mindfulness (from week 8 to 10 in Fig. 1) and for one week after applying mindfulness (week 11 in Fig. 1). We did not

collect data during the first three weeks of mindfulness practice (from week 5 to 7 in Fig. 1), since previous research, such as [25], has shown that mindfulness does not have any real effect until three weeks after starting the sessions, and this effect is continued at least one week after the end of the sessions. Therefore, our analysis accounted for weeks 10, 11 and 12 during which mindfulness was exercised, as well as week 13 (one week after the treatment application). In order to get balanced data (four weeks in each time period), we collected data for four weeks before applying mindfulness.

For both periods, we used the average, that is, the analysed response variable measurement is the average data for these four weeks. These periods are referred as *Pre* and *Post*, respectively.

Response variables are the effects studied in the experiment caused by the manipulation of factors [72]. Following a triangulation strategy [73], we used several source data to analyse the phenomenon under study. We collected both quantitative and qualitative data concurrently, identifying a response variable for each hypothesis that we aimed to test.

$H_{0,1}$ requires a variable to measure how much attention awareness the subject feels. This variable is referred to as **Attention Awareness**, measured on a 6–point Likert scale using a Mindful Attention Awareness Scale (MAAS) questionnaire whose Spanish version has been psychometrically validated [74]. The MAAS is a 15–item scale designed to assess a core characteristic of dispositional mindfulness, namely, open or receptive awareness of attention to what is taking place in the present.

The metric for $H_{0,2}$ is **Answered phone calls**, measured as the number of phone calls that the subject answers in a week (regardless of whether the subject managed to solve the issue).

The metric for $H_{0,3}$ is **Percentage of resting time**, which is measured as the percentage of time that the subject spends resting during a whole week.

$H_{0,4}$ requires a variable to measure the time that the subject spends waiting to answer a new phone call. This variable is named **Percentage of waiting for calls time**, and it is measured as the percentage of time that the subject spends waiting for a new phone call during a whole week.

The metric for $H_{0,5}$ is **Errors**, which is measured as the number of errors made by the subjects during phone calls per week.

$H_{0,6}$ requires a variable to measure how many issues are solved by the subjects during the phone calls. This variable is known as **Resolution**, which is measured as the percentage of tickets that are solved satisfactorily by the subject. It is the customer that decides whether the ticket is solved successfully. The minimum variable value is 0 if no ticket is solved, but there is no maximum value. Note that this value can be greater than 100%, as a phone call may, depending on its difficulty, generate several tickets. For example, the resolution rate is 200% if a phone call results in two tickets, and both are solved satisfactorily.

4.4. Design

In this experiment, it makes sense to use a design whereby we can measure the response variables before and after mindfulness workshop. This is common in areas like psychology or pharmacology in order to study the evolution of patients receiving a given treatment (or therapy) after a specified amount of time.

The **Time** factor follows repeated measures, i.e., within–subjects variable, since we have two levels of time (*Pre* and *Post* mindfulness) for all the subjects in the sample. However, the **Method** factor is a between–subjects variable with two levels too, the experimental and the control groups. While the experimental group practiced mindfulness, the control group was constituted as a waiting list, i.e. they did not receive any treatment during the same period, but did after the end of the study. This aims to promote their participation and to prevent dropout. Therefore, the chosen experimental design was a 2 (Time) *x* 2 (Method) *mixed factorial* design [75].

4.5. Experimental procedure

This section describes the procedure used to conduct the experiment, which is ordered sequentially below and summarized in Fig. 1. We describe how we divide subjects into the treatment group (where mindfulness was applied), and the control group (where no method was applied).

1. After a brief introduction to mindfulness, all subjects fill out a consent document, as well as a demographic questionnaire. This demographic questionnaire gathers information on each subject, such as gender, educational level, assigned department, type of contract, age, and previous experience (both in software engineering and at Accenture).
2. We randomly assigned subjects to control and treatment groups.
3. From Weeks 1 to 4, we gathered metric data without applying the treatment in order to identify subject job performance.
4. All subjects filled out the MAAS questionnaire at the end of Week 4 (after the recruitment talk and before starting the mindfulness workshop).
5. The treatment group attended the talk about mindfulness and its benefits before applying mindfulness. This talk lasted half an hour.
6. From Weeks 5 to 10, the treatment group practised mindfulness at a 15–minute session at the start of every working day (four days a week). All the sessions followed the same dynamics: the employees and the researcher responsible for

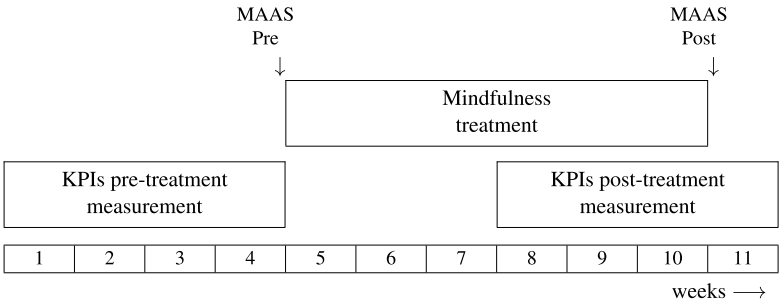


Fig. 1. Experimental schedule in weeks and data collection timing for KPIs and MAAS questionnaire.

conducting the session gathered in a meeting room; they all sat around the table; when they all were in silence, an alarm was programmed; during the first five minutes, the participants were guided in their body scan; then, during the remaining time, they were invited to focus solely on their breathing. Sometimes, the researcher invited the participants to return to breathing whether any thoughts or emotions had caused them to lose focus on their breathing.

7. At the end of Week 10, all subjects filled out the MAAS questionnaire again (after the mindfulness workshop ended).
8. Subjects who received treatment from Weeks 5 to 10 had to fill out a satisfaction questionnaire containing 5-point Likert scale questions and open questions about the experienced benefits of mindfulness.
9. During Week 11, no treatment was applied, but we gathered results from both groups to study whether the effect of mindfulness still remains.
10. After the experiment was completed, the control group also received mindfulness treatment (outside of the framework of the experiment). This was done in order to mitigate the motivation threat since all subjects wanted to learn mindfulness.
11. After finishing this second round of the mindfulness workshop, the subjects in the experimental group also completed the satisfaction questionnaire. The results of this questionnaire were aggregated with the results of the treatment group to identify the participants' perceived benefits after six weeks of practicing mindfulness.

Fig. 1 shows a classification of weeks between *Pre* and *Post*, the terms used from now on to refer to the time before and after applying the treatment, respectively.

4.6. Experimental material

The material used to conduct the empirical study, available in the laboratory package [76], consisted of the following items:

- The presentation slides used for participant recruitment.
- The questionnaire used for subject demographic classification and consent to anonymous participation in the study.
- The mindfulness workshop opening slides.
- The MAAS questionnaire from [71].
- The mindfulness workshop closing slides.
- The participant satisfaction questionnaire with respect to the practice of mindfulness.

4.7. Participants

Accenture is an international software development company with thousands of employees around the world. We focus our experiment on the delegation of Seville, where two maindifferent roles arise. Role N1 applies to technicians dealing with the end user requests received by phone. The requests are queries related to problems, difficulties or unanticipated situations/incidents experienced by end users working with the health information system. Role N2 refers to supervisors that manage the call centre department. Apart from technical issues, they deal with tasks, such as shift scheduling, incentive planning, employee performance monitoring, etc.

Since $H_{0,2}$ to $H_{0,6}$ focus on response variables related to technical issues, our sample includes N1 participants to analyse the above hypotheses. Therefore, the sample size for these hypotheses is composed of 27 subjects recruited voluntarily from N1 employees. Of the participants, 13 were assigned to the treatment group and 14 were placed in the control group. Our sample of N1 participants have different experience levels, which could have an undesired effect on the response variables. In order to avoid this threat, N1 participants were divided into three sets, or strata, by experience (high, medium and low). We applied stratified sampling, where random sampling is applied within the strata in order to respectively assign participants to the experimental or control groups. Both control and treatment groups received the mindfulness treatment, although members of the control group received the treatment after the experiment was complete. Even though

Table 2
Demographic data of the experimental subjects.

Variable	Levels	Participants			
		Experimental Group		Control Group	
		n	%	n	%
Gender	**Male**	14	25%	18	32.14%
	Female	10	17.86%	6	10.71%
	Unspecified	1	1.79%	7	12.5%
Education Level	**Unspecified**	1	1.78%	7	12.5%
	High School	0	0.00%	1	1.78%
	Vocational Training	1	1.78%	5	8.92%
	Advanced Vocational Training	19	33.92%	16	28.57%
	Associate Degree	3	5.35%	2	3.57%
	Bachelor Degree	1	1.78%	0	0.00%
Service	**N1**	13	23.21%	14	25%
	N2	12	21.43%	17	30.36%
Type of contract	**Unspecified**	1	1.78%	6	10.71%
	In-house	15	26.78%	13	23.21%
	Temping agency	9	16.07%	12	21.42%
Variable		Experimental Group		Control Group	
		Mean	SD	Mean	SD
Age		31.00	6.23	32.00	5.9
Work experience in IT (measured in years)		10.33	6.53	9.71	5.49
Work experience at the company (in years)		5.56	4.78	6.23	4.45

the mindfulness application was not analysed within the control as part of the experiment, it is critical that the recruited participants should be motivated.

$H_{0,1}$ does not depend on technical issues. Therefore, a sample of both N1 and N2 employees can be used to analyse this hypothesis. Adding the 27 N1 subjects together with the 29 N2 subjects, we get a sample size of 56 to analyse $H_{0,1}$. Of these subjects, 26 were assigned to the treatment group and 30, to the control group.

Table 2 shows the demographics of the participants. These data highlight that most participants hold *advanced vocational training* qualifications and have an *in–house* contract type. Note that participants have lengthy experience both in IT jobs and at the same company. The mean work experience in IT jobs is around 10 years in both the experimental and control groups, whereas the mean work experience at the same company is around 5 years. Therefore, we can conclude that subjects are sufficiently experienced in all the routine work required to perform the experimental task defined in our experiment. Note that all subject characteristics (age, experience, type of contract, etc.) are well balanced across both groups.

4.8. Threats to validity

We have organized the threats to experiment validity according to the classification provided by [23]. We specify whether each threat is avoided, materialized or mitigated.

Conclusion validity. This threat is concerned with issues that affect the ability to draw the correct conclusions about relationships between the treatment and the outcome.

(1) *Low statistical power* is a threat that appears when the sample size is not large enough to reject a null hypothesis. In our experiment, the 27 subjects are split into two (treatment and control) groups, which reduces power. Even though we could not avoid this threat, we calculated the statistical power for each hypothesis in order to hazard a guess at when non-significant differences could be due to a low power.

(2) *Fishing* appears when the experiment has many measurements and not very specific predictions beforehand, which means that any measure can show a significant effect just because so many tests are analysed. Our experiment suffers from this threat.

(3) *Reliability of measures* refers to the fact that the use of the wrong metrics may lead to unreliable results. We avoided this threat since we did not define the metrics for our experiment metrics; they are part of the metrics that Accenture uses to track employee productivity. Therefore, we can rely on these metrics since they were defined by professionals not related to the experiment.

(4) *Reliability of treatment implementation* appears when the treatment is applied differently to subjects of the same sample. We avoided this threat since all subjects received the treatment from the same experimenter (the first author of this paper). Materials and lessons were the same for all subjects.

(5) *Random irrelevancies in experimental settings* appear when there are external factors that may possibly affect the results. This threat materialized for our experiment since the context may be different depending on the week in which we applied the metrics. The number or difficulty of phone calls may vary from week to week (or even from day to day). We tried to

mitigate this threat by analysing the average response variables by weeks. We focused on the average for Weeks 1 to 4 for the time before the treatment, and the average for Weeks 8 to 11 for the time after the treatment.

(6) *Random heterogeneity of subjects* means that when the group of subjects is too heterogeneous, these differences may affect the results. Our experiment mitigates this threat since all subjects have the same profile: they are all employees of the same company with similar knowledge of the field under experimentation.

Internal Validity. This threat is concerned with influences that may affect the response variable with respect to a cause-effect relationship of which the researchers are unaware.

(1) *History* appears when different treatments are applied to subjects at different times. We mitigated this threat by including time as a factor in our design in order to analyse possible differences before and after applying the treatment.

(2) *Maturation* appears when subjects react differently as time passes. This threat could materialize for our experiment since the experiment lasts for 12 weeks, and subject behaviour may evolve over this period. The Time factor in our experimental design helps us identify whether this maturation may affect the results.

(3) *Instrumentation* is the effect caused by the artefacts used for experiment execution. A poor artefact design has a negative effect on the experiment. We mitigated this threat since our metrics were extracted from indicators that existed previously at the company, and the MAAS questionnaire, which is currently in widespread use within the mindfulness context, was validated by other researchers. The MAAS questionnaire, although commonly used, may suffer some problems, such as participants with a large amount of confidence may indicate improvements in attention due to *social desirability bias*, and due to the tendency they have to repeat back what they just learned.

(4) *Selection* may affect results depending on how subjects are selected from a larger group. In our case, they were all volunteers interested in learning mindfulness. We mitigated this threat by randomly assigning the subjects who were to learn mindfulness as part of the experiment (treatment group) or after the experiment (control group). Irrespectively of whether or not mindfulness was applied as part of the experiment, all subjects were trained in mindfulness, which should imply that all subjects were equally motivated.

(5) *Mortality* appears when subjects leave the experiment before it is complete. Our drop-out rate was zero.

(6) *Diffusion or imitation of treatments* occurs when a control group learns about the treatment from the treatment group or when its members try to imitate the behaviour of the treatment group. We avoided this threat by teaching mindfulness in a separate room that was not accessible for control group subjects.

(7) *Compensatory rivalry* appears when a subject receiving less desirable treatments may be motivated to reduce the expected outcome of the experiment. We avoided this threat by training all subjects in mindfulness (as part of the experiment or after finishing the experiment).

(8) *Motivation* appears when the subjects that receive the treatment are more motivated using the instruments of the experiment than subjects of the control group. This threat mainly may arise in the MAAS questionnaire since the people that choose to attend mindfulness courses may be highly motivated.

(9) *Hawthorne effect* appears when you pay attention to a group of people, and they will do better for that attention instead of by the treatment. Given KPIs used as experimental metrics are frequently used by Accenture to measure the employee's productivity (out of the scope of the experiment), its impact would be present on all subjects of both groups. However, it is important to note that participants receive a course of their choice and actively engage in attending it, which naturally leads them to have expectations of improvement. So, the design of the experiment suffers from this threat.

(10) *Absence of an active control group* appears when the control group does not receive any intervention, so our design suffers this threat. Nevertheless, whether the control group receives some intervention, it is possible that subjects have an effect on the results because participants are doing something they believe may benefit them. So, between (i) introducing a placebo treatment in the control group (as we did in the original experiment [20]) where we are not completely sure whether it is a real placebo; or (ii) considering the control group as a natural group without intervention, we chose the second approach that integrates the waiting list strategies for the control group, i.e. it will receive the treatment after the end of the experiment. Even though this strategy is used in several experiments in psychology [77], its use is not exempt from criticisms [78]. So, the design of the experiment suffers from this threat.

Construct validity. This threat is concerned with generalizing the results of the experiment to the concept, or theory, underlying the experiment.

(1) *Inadequate pre–operational explanation of constructs* means that the experiment may not be clear enough if the underlying theory is vague. Our experiment suffers from this threat, since we have not analyzed in advance how mindfulness could affect the KPIs. Note that KPIs have not been defined by ourselves, but they are metrics used on a daily basis by Accenture to measure productivity of their employees. We have worked with these KPIs as response variables since we consider they have the potential to lead to meaningful results.

(2) *Mono–operation bias* appears when the experiment includes only one factor, in which case it may under-represent the construct and thus not give the full picture of the theory. We mitigate this threat by including time as a factor to analyse whether there are differences across weeks that could affect the results for mindfulness.

(3) *Mono–method bias* appears when hypotheses depend on a specific metric. There is a risk of the experiment being misleading if a single type of measure or observation is used that leads to measurement bias. We mitigated this threat using hypotheses that were related with each other (methodological triangulation). For example, resting time is related to the number of answered phone calls. Therefore, we will discuss the implications of these relationships.

(4) *Hypothesis guessing* appears when subjects figure out what is the goal of the experiment and act accordingly. Our experiment suffers from this threat since subjects may guess that we are evaluating the benefits of mindfulness. In an attempt to mitigate this threat, we asked about the pros and cons of mindfulness in the satisfaction questionnaire.

(5) *Evaluation apprehension* means that some people are afraid of being evaluated, which may affect the results. We mitigated this threat by recruiting volunteers and explaining the process right from the beginning. None of the volunteers declined to participate in the experiment.

(6) *Experimenter expectancies* appear when experimenters expect a specific result. We mitigated this threat by using metrics (KPIs used to measure employee productivity) that were already in place at the company. Therefore, experimenters cannot adapt the metrics to their expectancies.

External validity. This threat is concerned with conditions that limit our ability to generalize the results of our experiments to industrial practice.

(1) *Interaction of selection and treatment* appears when we have a population that is not representative of the population to which we want to generalize our results. We mitigated this threat by recruiting subjects from a company providing a help desk to solve software-related inquiries, software activities being the target of our research.

(2) *Interaction of setting and treatment* appears when the experimental setting or material is not representative of the context that we are studying. We avoided this threat since all the questionnaires and metrics were proposed by other researchers and are not specific to this experiment. The questionnaires are widely used in psychology, and the metrics are used by the company to analyse employee productivity.

(3) *Interaction of history and treatment* appears when the day on which the experiment is conducted may affect the results. Our experiment suffers from this threat since the number of phone calls and incident difficulty vary from day to day. In order to mitigate this threat, we opted to analyse the average for the four-week periods before and after applying the treatment.

(4) *Results generalization* appears when results cannot be generalized to contexts different from the context where the experiment was conducted. The experiment suffers this threat since it was conducted in one company, making it unsure whether it can generalize to a different context.

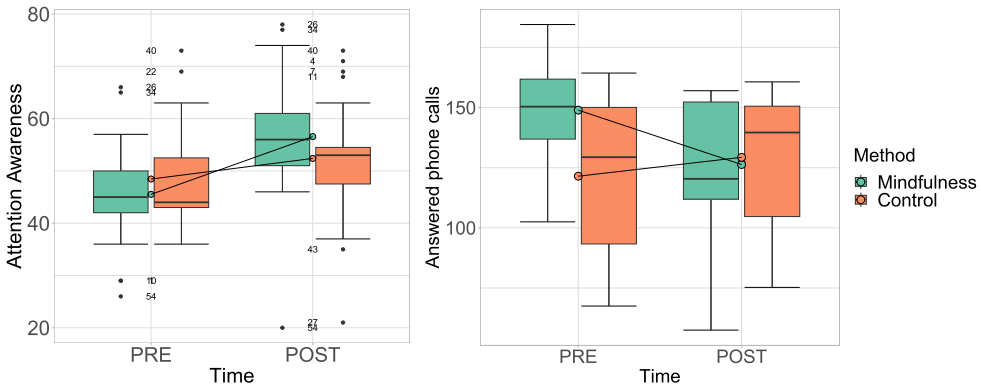
4.9. Data analysis

All the statistical analysis has been done with SPSS version 25. Descriptive data were analysed using box and whisker plots, which pinpoint differences between treatment medians and profile plots, which pinpoint differences between averages. In the following sections, the box and profile plots for each metric are shown in the same figure for ease of interpretation. Statistical testing to look for significant differences between treatments was based on a general linear model (GLM) repeated measures, and in particular 2 (Method) x 2 (Time) mixed-model ANOVA tests, as recommended by Gliner et al. [79]. This choice was based on the fact that we analysed two measures for the Time factor, one before and the other after applying mindfulness. In this case, we were interested in not only the changes between time, but also the differences between the interaction of Time*Method. We wanted to ascertain whether subjects that practised mindfulness experienced any differences with respect to the control group after the application of the treatment (*Post* level of the Time factor). As within-subjects variables we have used the response variable Time, while the between-subjects variable is Method. Degrees of freedom are 1 for Time and Time*Method, while for the error is 25.

There are two requirements for applying a GLM test: homogeneity of the covariance matrices and sphericity. Levene's test is used to check the condition of homogeneity of covariance matrices where the null hypothesis is that the observed covariance matrices of the dependent variables should be equal across groups [80]. All Levene's test p-values were greater than 0.05. Therefore, we cannot reject the null hypotheses of homogeneity of covariance, which means that the premises of the statistical tests are met in this regard. Mauchly's test is used to check the sphericity condition. In our case, however, there are only two levels of repeated measures (before and after applying the method). This precludes a sphericity violation [80], and the test is unnecessary. We regard the differences between treatments as being significant when the GLM p–value is less than 0.05.

For variables with significant differences according to the GLM, we calculated the degree of such differences using partial eta squared (η_p^2, i.e., effect size) [81]. It measures the proportion of variance explained by a given variable of the total variance remaining after accounting for variance explained by other variables in the model. The partial eta squared results were interpreted as follows [82]: values of less than 0.3 mean a significant, but weak, effect; values between 0.3 and 0.6 mean a moderate effect, and values greater than 0.6 mean a strong effect.

Statistical power is the probability of rejecting a false null hypothesis. In SPSS, power of a test refers to the ability of that test to detect a population difference as large as the actually observed sample difference. The significance level has been 0.05. Statistical power is inversely related to beta or the probability of making a type II error. In short, power = 1 – β. Power in software engineering experiments tends to be low, e.g., Dyba et al. [83] reports values of 0.39 for medium effect sizes and 0.63 for large effect sizes. Low values of statistical power mean that non-significant results could imply the acceptance of null hypotheses when they are false. Therefore, we calculated the power to find out whether our results were influenced by this widespread problem in software engineering.



(a) Attention awareness (b) Answered calls

Fig. 2. Profile and box plots of attention awareness and answered calls.

Table 3
Statistics for Attention Awareness.

Variable	P-value	Effect size	Power
Time	**0.006**	0.36	1
Time*Method	**0.01**	0.11	0.74

Table 4
Statistics for Answered Phone Calls.

Variable	P-value	Effect size	Power
Time	0.36	–	0.15
Time*Method	**0.04**	0.15	0.52

5. Results

This section analyses the results for each response variable according to the data analysis described above (descriptive data, GLM, partial eta squared and power). Raw data are available in the laboratory package [76] and descriptive data is in Appendix A.

5.1. Attention awareness

Fig. 2a shows the box and profile plots for the Attention Awareness response variable. Medians for the *Pre* period are almost the same for the mindfulness group and the control group, which makes sense since mindfulness has not been yet applied. For the *Post* period, Fig. 2a shows that the level of attention awareness is higher, mainly for the subjects that practised mindfulness.

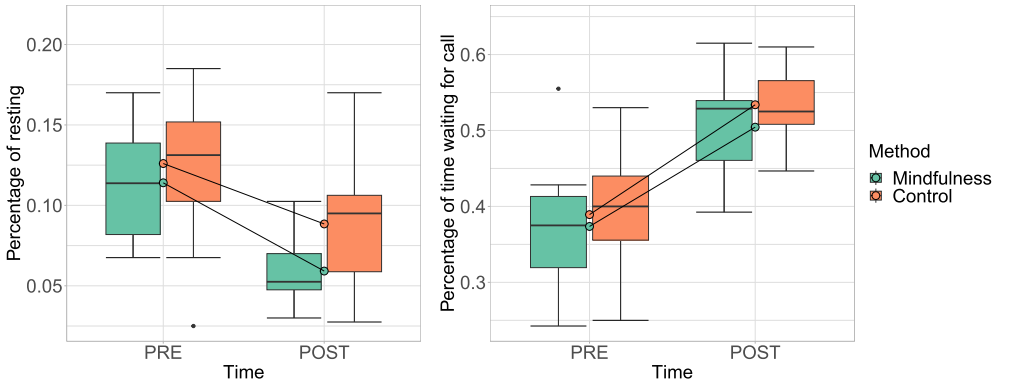
Table 3 shows that the differences for Time were significant with a moderate effect and a high statistical power. We also have a significant result for the Time*Method interaction with a weak effect and a high statistical power. During the *Post* period, all subjects yielded higher values for Attention Awareness. Subjects exercising mindfulness achieved higher attention scores than participants in the control group. Differences between the control group and the treatment group are more evident during the *Post* period (see Fig. 2b).

Therefore, we can reject the null hypothesis $H_{0,1}$ and state that *there are significant differences in attention awareness when mindfulness is practised*. We can conclude that mindfulness leads to improved attention awareness.

5.2. Answered phone calls

Fig. 2b shows the box plot for the Answered Phone Calls response variable. This figure shows that the number of answered phone calls is lower during the *Post* period, and this drop is even greater for the group that works with mindfulness.

Table 4 does not yield significant differences for the Time factor, whereas the Time*Method interaction is significant. Significance in this interaction means that the number of phone calls answered by subjects that were exposed to mindfulness was smaller with respect to the control subjects in the *Post* period. The partial eta squared shows a weak effect size, and statistical power is medium. This low power may hide larger differences between treatments; more sample size is required to analyze this idea.



(a) Percentage of resting time

(b) Percentage of waiting for calls time

Fig. 3. Profile and box plots of resting and waiting time.

Table 5
Statistics for Percentage of Resting.

Variable	P-value	Effect size	Power
Time	**0.00**	0.68	1
Time*Method	0.291	–	0.19

Fig. 2b shows the profile plot of the Time*Method interaction. We find that the number of answered calls is lower for the group applying mindfulness, whereas they increase for the control group.

Therefore, we can reject the null hypothesis $H_{0,2}$ and state that *the number of answered phone calls decreases when mindfulness is practised. The number of phone calls answered by subjects with mindfulness dropped.* Although it might appear that participants who practice mindfulness are less productive, the actual productivity is not as simple, since there are no significant differences between groups in terms of problem resolution and percentage of waiting time. Furthermore, due to the demonstrated increase in awareness, it is possible that technicians are more attentive to the problem, engaging with the end–user to resolve the issue, causing longer call duration. We recommend interested readers the discussion provided in Section 6, where we delve deeper into this topic.

5.3. Percentage of resting

Fig. 3a shows the box plot for the Percentage of Resting response variable. We find that this percentage drops for both the treatment and the control groups in the *Post* period. However, this reduction is slightly higher for mindfulness.

Table 5 shows significant differences for Time, where there is a drop in resting time during the *Post* period. Time*Method interaction does not yield significant differences. The partial eta squared shows a large effect size, and the power is optimum. Therefore, differences between the *Pre* and *Post* time periods are large, and we have a large enough sample size to back this finding.

Accordingly, we cannot reject the null hypothesis $H_{0,3}$ and state that *there are no significant differences in the resting time when mindfulness is practised*. Even though the results for mindfulness practitioners are not significant, there is a trend that shows a drop in the resting time for subjects that practised mindfulness.

5.4. Percentage of waiting for calls time

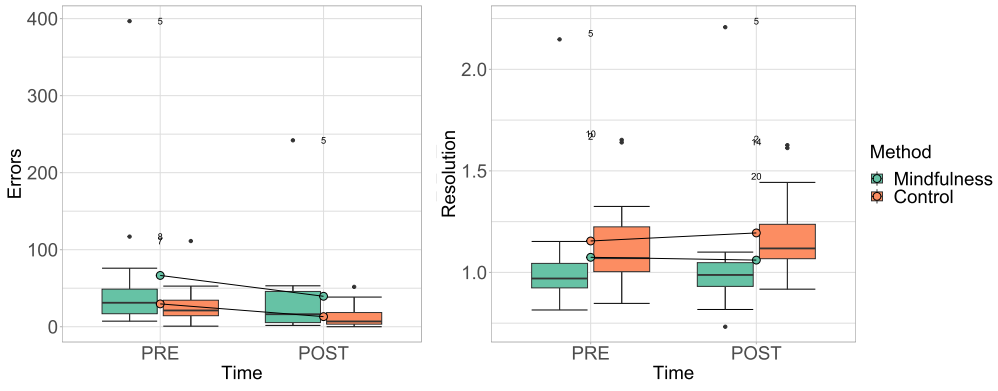
Fig. 3b shows the box and profile plot for the Percentage of Waiting for Calls Time response variable. This figure shows that waiting time is longer during the *Post* period, but slightly shorter for the mindfulness treatment. The third quartile for the control group in *Post* shows a higher percentage of waiting time. Therefore, subjects who practised mindfulness are on the phone answering questions for a longer time than subjects in the control group during the *Post* period. Therefore, they spend less time waiting to take new calls.

Table 6 yields significant differences for Time. The percentage of waiting for calls time is greater during the *Post* period. The Time*Method interaction does not yield significant results. Time differences between weeks have a strong effect with a high statistical power, which means that there are large differences between *Pre* and *Post*, and the sample size is large enough to be able to state this conclusion.

Therefore, we cannot reject the null hypothesis $H_{0,4}$ and state that *there are no significant differences in the waiting for calls time when mindfulness is practised*.

Table 6
Statistics for Percentage of Waiting for Calls Time.

Variable	P-value	Effect size η_p^2	Power
Time	**0.00**	0.73	1
Time*Method	0.45	–	0.11



(a) Errors (b) Resolution

Fig. 4. Profile and box plots of errors and resolution.

Table 7
Statistics for Errors.

Variable	P-value	Effect size	Power
Time	**0.00**	0.28	0.84
Time*Method	0.58	-	0.08

Table 8
Statistics for Resolution.

Variable	P-value	Effect size	Power
Time	0.96	-	0.05
Time*Method	0.62	-	0.07

5.5. Errors

Fig. 4a shows the box plot for the Errors response variable. There is a similar drop in both control and treatment groups during the *Post* period.

Looking at Table 7, we find that there are significant differences for the Time factor. Supplementing this result with the box plot in Fig. 4a, we state that Errors are significantly lower during the *Post* than during the *Pre* period. Even though the drop in the number of errors cannot be said to be significant for the mindfulness treatment (there are no significant differences in Time*Method), the results suggest that there is a sharper decrease in errors for the mindfulness treatment than for the control group. The partial eta squared for the Time factor shows a weak effect size and a high statistical power. Therefore, we claim that although there are differences between *Pre* and *Post* their effect size is low.

Therefore, we cannot reject the null hypothesis $H_{0,5}$ and state that we have no evidence that errors decrease after applying mindfulness, even though the analysis of descriptive data reveals a sharper downward trend.

5.6. Resolution

Fig. 4b shows the box plot for the Resolution response variable. The control group yields slightly better values for both time periods. Table 8 shows no significant differences for Time or Time*Method. In both cases, the statistical power is low. Therefore, a bigger sample size may yield other results.

We do not draw any conclusions with respect to this variable due to the resulting low statistical power.

Table 9
Satisfaction Questionnaire.

ID	QUESTION
Q1	Introductory talk on mindfulness was interesting.
Q2	During daily sessions, I felt comfortable in the room and with the job.
Q3	I did not manage to calm my mind at all and found it impossible to pay attention to my breathing during the first week.
Q4	As the days went by, my mind wandered less during the sessions.
Q5	The body sweep at the beginning makes it easier for me to focus on breathing later.
Q6	I intend to continue with the daily practice of mindfulness.
Q7	I think I have learned a tool that can be useful to improve my quality of life.
Q8	I think I am learning to observe my mind and avoid racing thoughts
Q9	I find that it is easier for me to focus on a single task after practice.
Q10	I sleep better or wake up more rested.
Q11	It is easier for me to focus on the present, enjoy nature or be more aware of reality.

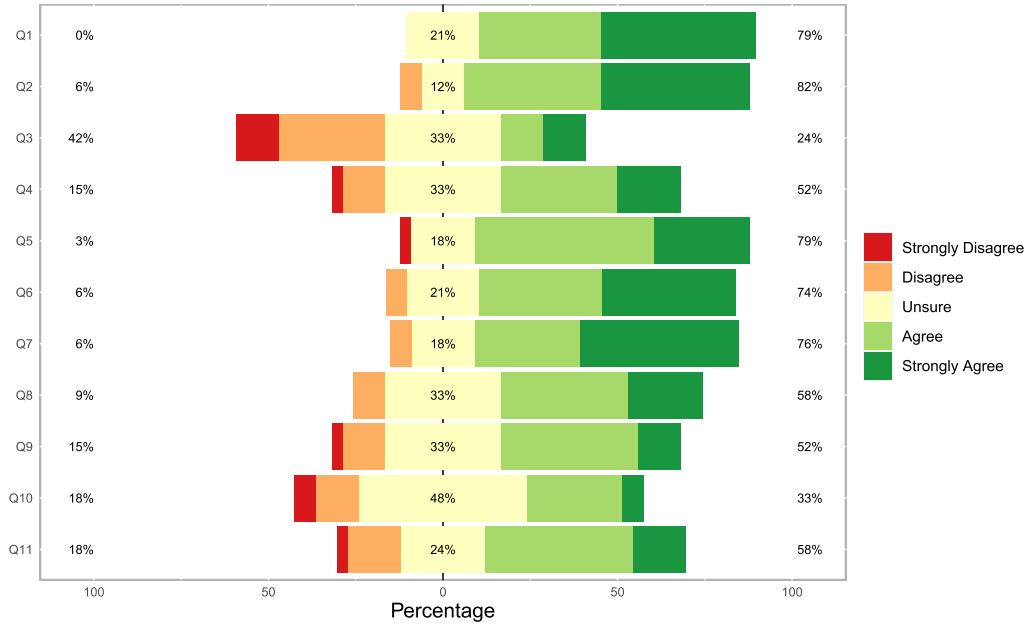


Fig. 5. Diverging stacked bar chart of the responses to satisfaction questionnaire (9).

5.7. Survey on satisfaction after the practise of mindfulness

After subjects attended to the corresponding mindfulness workshop, they completed the satisfaction questionnaire shown in Table 9.

The goal of such questionnaire (that included 11 questions on a 5-point Likert scale) is to discover the perceived benefits of mindfulness practitioners after the continued mindfulness practise.

Regarding this survey, the discussion is exclusively based on descriptive data, since we have no control group available for comparison of responses. Therefore, these data provide pointers to what subjects think about the mindfulness workshop and their experience. The sample size is larger than the number of subjects who performed the experimental task, because we have also gathered responses from the control group who participated in a second edition of the mindfulness workshop later outside the context of this experiment.

Fig. 5 shows a diverging stacked bar diagram, as recommended in [84] for plotting survey responses using Likert scales. In such diagrams, the percentages of respondents with positive responses are shown to the right of the vertical line representing zero, the percentages of respondents with negative responses are shown to the left. The percentage of respondents with neutral responses is divided in half and shown in grey in the centre. The interpretation of this type of diagram is mainly based on the total percentage to the right or left of the vertical zero line, therefore these percentages are shown on the X-axis. Each row of the plot represents one question of Table 9. These questions have been assessed using five-level Likert scales with symmetry around a neutral value, with the extreme values being labelled as “Strongly disagree” and “Strongly agree”. Most of the responses to the questions (80%) fall in the “Agree” or “Strongly agree” categories. This means that the level of satisfaction with the mindfulness practice in our sample is really high. Satisfaction levels are low (more than a 40% of negative responses) for Q3 reporting that most subjects began to calm their minds in the first week of the treatment already. Finally, the limited impact of the practice on sleep quality (see Q10 in Fig. 5), suggests that the mind-

Table 10
Summary of outcomes of the empirical study.

Response Variable	Time * Method	P–value	η_p^2	Power
Attention awareness	control<mindfulness	**0.01***	0.11	0.74
Answered phone calls	control>mindfulness	**0.04***	0.15	0.52
Percentage of resting	not significant	0.29	–	0.19
Percentage of waiting for calls time	not significant	0.45	–	0.11
Errors	not significant	0.58	–	0.08
Resolution	not significant	0.62	–	0.07

fulness workshop duration may have been too short to produce noticeable effects on sleep quality, as has been revealed by previous studies [85,86].

6. Discussion

This section aims to interpret the results yielded by the statistical analysis. This information is rounded out with the responses to the open questions of the satisfaction questionnaire about the benefits that subjects experienced after six weeks of mindfulness practice. Below, we discuss the results for each response variable detailed in Section 5 and summarized in Table 10. Table 10 focuses on the results for the interaction between time (*Pre* and *Post* periods) and Method (mindfulness or nothing) (*Time*Method* columns) since this is the target of our research. The analysis addresses the differences between the control and the treatment groups in the *Post* period.

Attention awareness results for *Time*Method* show that that mindfulness increases attention awareness at *Post*. Several works in the literature, such as Black et al. [87], report an improvement in attention awareness measured using MAAS after applying mindfulness. This improvement leads to a reduction of subject stress levels, as was found by previous research [88,27]. Besides, the responses to the open questions about the benefits of mindfulness underscore this idea, with several subjects stating that "mindfulness enhances relaxation and tranquillity, reducing stress (subject ID-17)". Other subjects' stress–related claims are, for example, "I do not get carried away by stress in a tense situation (subject ID-11)", "My attention has improved, and my eye twitch has disappeared (subject ID-21)". Other general comments on satisfaction are: "It would be great to be able to continue with mindfulness practice, it has been a wonderful workshop and I am happy with the results (subject ID-2)", or "I loved the experience. I think it's a good idea to do it at work (subject ID-16)".

The number of **Answered phone calls** is reduced significantly with mindfulness, since *Time*Method* yields significant differences. This means that subjects with mindfulness do not answer so many phone calls as subjects in the control group. Considering that both groups are working at the same time, have the same experience, and have the same queue of customers, this must mean that subjects with mindfulness spend more time with the customers per call. Therefore, this may lead to subjects tending to more actively listen to customer issues. Previous research, such as Heijer et al. [69], agrees with the idea that mindfulness helps improve listening during conversations. There are comments in the satisfaction questionnaire that support this idea, such as "I pay more attention to customers (subject ID-26)" or "I look at the customer's situation in a different way (subject ID-16)". Note importantly that there are no significant differences in other primary productivity metrics such as Resolution, which leads to conclude that although answering fewer phone calls, subjects who practice mindfulness are able to solve the same number of problems, thus they have a better ratio of problem solving. Furthermore, there are no significant differences neither in terms of the Errors variable, nor for Percentage of waiting for calls time variable, thus the actual performance of the subjects is similar.

With respect to the **Percentage of resting** for *Time*Method*, there are no significant differences between the mindfulness and the control groups after the treatment has been applied, even though there is a slight downward trend in resting time with mindfulness. Previous works have analyzed the correlation between work engagement and a reduction of cognitive load [89]. Even though there are works such as Malinowski et al. [90] which conclude that subjects that received mindfulness improve their work engagement, we have no significant results to support such statement. Comments in the responses to the open questions of the satisfaction questionnaire also underscore this point. One subject claimed that "I wake up more rested, and my pace of life has changed (subject ID-22)". Another subject stated that "The sense of calm I get from meditation lasts the whole day (subject ID-41)".

With regard to the **Percentage of waiting for calls time**, *Time*Method* yields no significant differences between the control and mindfulness groups, but there is an appreciable trend suggesting that subjects practising mindfulness spend less time waiting for calls. Again this finding must mean that subjects practising mindfulness spend more time on the phone attending to individual customers. This result is consistent with both of the above metrics: Subjects exercising mindfulness spend more time on the phone, take fewer breaks and spend less time waiting for calls because they are occupied answering concerns from other customers. The results for these three variables suggest that subjects with mindfulness work harder than control group subjects.

With regard to **Errors**, *Time*Method* did not show up significant differences between the mindfulness and control groups, where the number of errors at *Post* is similar for both the mindfulness and control groups. This means that, even though mindfulness improves attention awareness and reduces the number of phone calls, the number of errors is quite similar, and the error rate is not affected by the treatment. Therefore, mindfulness improves how subjects feel and how they

communicate with customers, but it does not impact the number of errors made at work. The small sample size used in this experiment may be the reason for such a low effect. None of the responses by subjects to the open questions of the satisfaction questionnaire claim that mindfulness reduces or increases the number of errors. Therefore, we cannot conclude that mindfulness affects the number of errors.

With regard to **Resolution**, *Time*Method* did not identify any significant differences. This means that even though subjects with mindfulness rest less and spend more time answering phone calls (they spend less time waiting for new calls), there is no significant increase in resolution rates over the control group. Therefore, the main benefits of mindfulness are that it reduces emotional exhaustion and improves job satisfaction, as claimed by Hülsheger et al. [91]. Participant responses to the open questionaire did reveal a slight improvement in their perceived productivity, such as "I focus more on tasks than I used to do automatically (subject ID-26)" or "I take fewer breaks, and I am more productive (subject ID-20)".

In conclusion, addressing our research questions RQ_1, RQ_2, and RQ_3, mindfulness positively affects Accenture help desk agents' attention awareness, participants report high levels of satisfaction with the practice, and it has a subtle effect on agents' performance. As a result, we confirm that the practice of mindfulness improves attention awareness and satisfaction of help desk agents in a software development company. Probably, these improvements at the personal level should lead to improvements at the performance in the medium term, although we only found significant differences in the number of answered phone calls. Maybe, this is due to the limited duration of the study and the low statistical power. This significant result means that mindfulness implies employees spending more time on the phone trying to solve customer incidents with higher attention awareness. Considering that other variables do not yield significant differences, this means that subjects spent more time on phone without reducing satisfaction, answered phone calls, or resolution. This leads us to think that subjects with the mindfulness treatment aim to solve customer's problems with more motivation than the subjects of the control group. Even though the differences were not significant, we also identified other trends in the descriptive data: i) mindfulness reduces break times; ii) mindfulness reduces the time that subjects spend waiting for calls; iii) mindfulness does not affect the number of errors or the percentage of problems solved.

7. Conclusions

This paper reports an experiment conducted to analyse the application of mindfulness at a software engineering company offering technical assistance to solve customer problems over the phone. We studied two factors: Time (before and after applying mindfulness) and Method (use or otherwise of mindfulness). We can conclude that mindfulness significantly improves attention awareness and reduces the number of phone calls. The descriptive data for the other analysed variables show a trend suggesting that mindfulness reduces the percentage of resting time and increases the time that technicians spend attending customers, even though the results are not significant. Descriptive data for the number of errors and incident resolution show similar values between the treatment and control groups. Comparing these results (at a real software engineering company) with our previous family of experiments on mindfulness (with students), we can state that performance-related and attention awareness metrics show a positive trend for mindfulness.

This experiment has a number of limitations that should be highlighted. The first limitation is the sample size. Even though we have 56 subjects for hypothesis $H_{0,1}$ and 27 subjects for hypotheses $H_{0,2}$ to $H_{0,6}$, the statistical power for some of the results of the statistical tests is poor. Some of the trends identified by the descriptive data could perhaps be significant with a larger sample size. The second limitation is that the results can only be generalized to the setting in which the experiment was conducted: solving customer technical problems. These results cannot be generalized to developers or analysts developing a software system from scratch.

Our contribution has several strengths worth mentioning. First, several response variables are related to each other. For example, a number of response variables suggest that mindfulness increases the time employees spend with each customer. Response variables such as Answered phone calls, Percentage of resting, and Percentage of waiting for calls time show that subjects that practised mindfulness spend more time dealing with customer issues than the control group (although the differences for Percentage of resting and Percentage of waiting for calls time are not significant). This relationship among response variables underscores the idea that conclusions are not chance findings. Second, we analysed data extracted from 4 weeks during *Pre* and 4 weeks during *Post* for each group (control and mindfulness). This rules out the possibility of other sporadic factors not accounted for in the experiment affecting the results. Third, the analysis of results combines both quantitative and qualitative analysis. Not only does this mean that we can analyse data from a statistical point of view, but we can also identify the subjective opinions of subjects, which tend to be consistent with the benefits of mindfulness cited in previous research published in the literature. Fourth, our experiment included two employee roles: technicians and managers. This encourages us to think that it is possible to generalize the results for attention awareness to any software engineering professional working on technical problem solving.

As future work, we plan to replicate the experiment at other companies within the same context. This will allow us to increase the statistical power and check if the trends identified in the descriptive data could be considered as significant results. Replications will include the study of the correlation between mindfulness and an enhancement of empathy with the customer. Another future line of research is the replication of the same experiment at software development companies. While the experimental design would be unchanged, the roles and profiles of participants would be different. This would help us advance towards the aim of generalizing the results to more software engineering-related jobs. We also plan to focus future studies on emotional aspects, such as empathy or ease of listening to other people. While a lot of previous

research makes claims with respect to the benefits of mindfulness in this context, this falls outside of scope of our current analysis.

Laboratory package

The laboratory package of the current study is available on the ZENODO PLATFORM [76]. Apart from the experimental material described in Section 4.6, the laboratory package also includes: i) raw data files in both CSV and sav formats; ii) descriptive statistics, measures of central tendency and dispersion and graph-generating scripts in R, and iii) GLM mixed-model ANOVAs using IBM SPSS Statistics 26.

CRediT authorship contribution statement

Beatriz Bernárdez: Term, Conceptualization, Writing – Original Draft, Investigation, Validation. **José Ignacio Panach:** Writing – Original Draft & Writing Review & Editing, Formal analysis. **José A. Parejo:** Term, Conceptualization, formal analysis, Visualization, Data Curation. **Amador Durán:** Methodology, Supervision. **Natalia Juristo:** Visualization, Writing – Review & Editing. **Antonio Ruiz-Cortés:** Conceptualization, Resources, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.scico.2023.102977.

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