



## **Where attention goes, energy flows : enhancing individual sustainability in software engineering**

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# Where attention goes, energy flows — enhancing individual sustainability in software engineering

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## ABSTRACT

Software engineers are plagued by the same troubles as many others in highly skilled jobs and digitized environments: Ever-expanding to-do lists, time to market pressure from management, deadline-driven development, continuous interruption during working tasks, and the juggle of balancing that with other areas of life (physical, mental and emotional health, family, household, finance, friends, hobbies and community service). These demands of life in combination with a seemingly ever-increasing pace wear or burn out many people in the long run. Specifically, as software engineers, this also leads to decreased creativity and less efficiency in problem-solving. Generally offered solutions are reducing screen time and spending more time outdoors, both of which are hard to do within the work of a software engineer. On a meta level, if the developers of the systems that run most of our world do not develop individual sustainability with a balanced pace of life, that imbalance propagates into the systems we develop (similar to Conway's Law). We argue that mindfulness practices like yoga poses (asanas), breathing practices, and meditation exercises can help individually, and even more effectively in combination. In this exploratory paper, we discuss related work that explores the application of these mitigations in other application domains and propose a research agenda to explore their use within software engineering education and practice.

Engaging with mindfulness practices in the context of software engineering promises to enhance creativity and cognitive problem-solving skills, leading to more efficiency and effectiveness during software development and increased individual sustainability. This, in turn, leads to better team spirit as well as increased economic profit, both in terms of maintaining human capital and customer contract deliverables.

## CCS CONCEPTS

• **Social and professional topics;**

## KEYWORDS

individual sustainability, software engineering, meditation, breathwork, yoga

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## 1 INTRODUCTION

“Always ask yourself if what you are doing today is getting you closer to where you want to be tomorrow.”  
— Paulo Coelho

Lavallée and Robillard [32] found in a ten month study that many decisions made under the pressure of certain organizational factors negatively affected software quality. These organizational factors are manifold and, while they can partly be addressed by management, the individual developer needs to face the stress caused by the resulting pressure. Stress factors have a negative influence on cognitive task performance [35].

The pace of life and the numerous demands of life are a topic that has us concerned as professionals as well as in our private lives, as described by Brown [7] in her book “Speed: facing our addiction to fast and faster—and overcoming our fear of slowing down”. Especially in the US, but spreading almost globally, over-scheduling and double-booking have been signs of progress and belonging for two decades. Progress equals fast, and fast equals success, which is a recipe for addiction [7].

Software developers are often willing to work late for project deadlines because “forgoing sleep appears to be a badge of honor in the programmers and start-up communities” [16], leading to burnout [33, 34]. Sleep deprivation and disrupted circadian rhythms may lead to adverse metabolic consequences [8], all the way up to increasing the risk for developing cancer [23]. This also leads to economic losses, recognized in the US, but also United Kingdom, Japan, Germany, and Canada [22], estimated between \$280 billion and \$411 billion for the US in 2020, depending on the scenario, and between \$88 billion and \$138 billion for Japan.

*Problem:* We are dealing an unsustainable working style, due to many factors, and there is need for interventions. As a mitigation of those individual and economic sustainability risks, what should be our professional code of conduct in terms of looking after ourselves? It is recognized that we have legal obligations as well as ethical and social ones. But what are our professional obligations? We as software engineers are overcoming some of the clichés of living on coffee and cold pizza, but we are far from being stereotyped as healthy and wholesome profession.

*Impact:* If our software developers do not have good self-care practices that support individual sustainability, how do we prevent that from informing their designs? Conway’s law [11] has been found to be applicable for propagating institutional structure and values into software code by Herbsleb and Grinter a long time ago [24], even in scientific computing [2]. If unsustainable behavior propagates into the systems they develop, using these software systems will not be exposing the users to more sustainable behavior either. Lastly, this work contributes to the third Sustainable Development Goal “ensure health and well-being for all” [21].

*Research Objective:* To explore the use of mindfulness practices in the context of software engineering education and practice. This needs to be broken down into a number of research questions, amongst them. (1) how to integrate mindfulness practices effectively into software engineering education and practice in the least intrusive way, (2) how to measure the effectiveness of such interventions in terms of cognitive abilities, energy levels and self perception and (3) how to predict good timing for interventions such that they don’t disturb moments of flow but enhance energy levels when needed.

*Contribution:* This paper proposes a vision and research agenda that detail the objective and questions mentioned in the previous paragraph.

*Outline:* The next section introduces background and related work, followed by preliminary work, a vision of the future, the research agenda, a discussion of the research agenda, and concluding remarks.

## 2 BACKGROUND AND RELATED WORK

### 2.1 Individual sustainability

Penzenstadler and Femmer [39] initially defined individual sustainability in the context of software engineering according to Goodland [19]: Individual sustainability refers to the maintenance of the private good of individual human capital. The health, education, skills, knowledge, leadership and access to services constitute human capital.

Becker et al. [4] refined this into: “The individual dimension covers individual freedom and agency (the ability to act in an environment), human dignity and fulfillment. It includes the ability of individuals to thrive, exercise their rights and develop freely.”

In their literature study, Nazir et al. [36] shortened this to “Individuals’ self-respect, education, freedom, physical and mental well being”.

Pappas adds that “Individual sustainability includes possessing a well-developed and demonstrated value system that acknowledges the importance and interconnectedness of all global biological and social systems, and our appropriate place within them.” [37]. We refer to his definition of a sustainable individual later in this paper.

### 2.2 Yoga Basics

In Sanskrit, the word *Yoga* means union, or “to yoke” as a metaphor to bring together body, mind and spirit. The word *Yoga* originates from the Sanskrit word *Yuj* (literally, “to yoke”) and is generally translated as “union” or “integration” — to yoke, attach, join, or

unite. The “union” referred to here is that of the individual soul with the cosmos, the Supreme; of the small “self” of ego and individual identity with the larger “Self” or “Spirit” of which we are all a part. According to the Ministry of Ayush, India, Yoga is a discipline to improve or develop one’s inherent power in a balanced manner. It offers the means to attain complete self-realization<sup>1</sup>.

The practice differentiates eight different aspects: moral conduct, observances, poses, breath control, sense withdrawal, concentration, meditation, and enlightenment. The enlightenment is the state of peace of mind that yoga practitioners aim to reach by practicing the first seven aspects.

### 2.3 Proven Benefits

There are many studies that prove the physical and mental benefits of yoga and its practices [44, 52].

Wallace [49] reported already in 1970 on the benefits of meditation. Oxygen consumption, heart rate, skin resistance, and electroencephalograph (EEG) measurements were recorded before, during, and after subjects practiced a technique called transcendental meditation. There were significant changes between the control period and the meditation period in all measurements. “During meditation, oxygen consumption and heart rate decreased, skin resistance increased, and the electroencephalogram showed specific changes in certain frequencies. These results seem to distinguish the state produced by transcendental meditation from commonly encountered states of consciousness and suggest that it may have practical applications” [49].

Pital et al. [40] investigate the relationship between Yoga and Heart Rate Variability (HRV), a significant characteristic to determine the condition of heart. Hernando et al. [25] study the pulse rate variability (PRV), as that metric has been proposed as a surrogate of HRV.

According to Dev et al. [13], yoga improves regional cerebral oxygenation at prefrontal regions during the attention task.

Supoo and Sittiprapaporn [44] studied the effect of yoga poses on brain waves using a tool called MindWave Mobile and found a significant increase of alpha and theta brainwaves. Alpha brainwaves are detected in highly focused but calm states of mind, and theta brain waves in deeply introspective states of mind.

Tiwari and Tiwari [48] used Electroencephalogram signals are for measuring the brain’s response to yoga poses and music, generated by millions of nerve cells known as neurons. Jaeger et al. [29] explore the use of adaptive architectures for breathing control.

Bernardez et al. [5, 6] performed experiments showing that the practice of mindfulness significantly improves conceptual modeling efficiency. Regarding conceptual modeling effectiveness, an improvement was observed in practice, even though the analysis showed that the improvement was not statistically significant. Their replication led to the same conclusions as the original study, the adequacy of the original experiment was confirmed and the credibility of the results increased. Consequently, the practice of mindfulness can improve the efficiency of Software Engineering students in the development of conceptual models. They pointed out that specifically introverts may benefit, and the software field

<sup>1</sup><http://ayush.gov.in/about-the-systems/yoga/definition-yoga>

is dominated by introverts [9]. This experiment is built on in the research agenda.

## 2.4 Work Breaks for Health

Work breaks as promoted by Wendell Taylor, are “easy-to-implement workplace policy designed to improve employee health, increase productivity, and lower health care costs” [47]: Transforming work breaks promotes health [45]. They are also referred to as Booster Breaks [46], and they prevent chronic disease in seated work environments [47].

Furthermore, Beck et al. [3] have explored what makes a moment during daily work opportune for reminding and conducting a physical exercise, of how to identify these moments with sensing technology, and how to provide unobtrusive but effective notifications during these moments.

We build on these studies in the research agenda.

## 2.5 Creativity Theory

Finally, creativity theory [17, 41, 42] states that we need incubation time to let ideas ripen, where we do something different. Horkoff and Maiden [27] use this for requirements engineering, specifically in the elicitation phase of projects to discover new requirements. Beyond that, creativity is also needed in software design and solving other challenges.

## 3 PRELIMINARY WORK

The author of this paper is a certified yoga teacher registered with the Yoga Alliance<sup>2</sup> and has conducted a series of small interventions using simple yoga poses and breathing exercises in class with students since 2016. The courses were Bachelor’s as well as Master’s level courses in Software Engineering, Requirements Engineering, and ICT for Sustainability. Students were always willing to participate, and many commented positively on the exercises in the (formal and informal) teaching evaluations.

At a summer school in 2019 in Uganda, I got invited as lecturer and, in addition to the content on ICT4S, offered a yoga class for the students. Some of them were enthusiastic to continue the practice, so I made two little videos for them such that they could keep practicing<sup>3</sup>.

At research conferences like ICT4S and RE as well as at a Dagstuhl seminar, I received requests to guide yoga sessions, and the attendance was always worth getting up extra early. All of the listed examples so far have been community service and not research, but they show that I have been willing to put in the practice without wondering whether there was research merit to it. Making the impact of these practices more visible and maybe even measurable is just a further opportunity for helping people get a little healthier and individually sustainable.

For Spring 2020, I am planning a replication of Bea Bernardez’ experiment [5] on the effects of a voluntary meditation practice on the cognitive abilities needed to perform conceptual modeling. This replication is under preparation right now in collaboration with the original author of the study.

<sup>2</sup><http://yogaalliance.org>

<sup>3</sup>Morning sequence <https://youtu.be/WzS8VskFdcc> and core strengthening sequence [https://youtu.be/AXYta\\_0gIOM](https://youtu.be/AXYta_0gIOM)

## 4 VISION OF THE FUTURE

### 4.1 Revisiting “Flourishing indefinitely”

Ehrenfeld and Hoffman’s “flourishing indefinitely” [15] definition of sustainability comes to mind. In their book, Ehrenfeld and Hoffman show aspects of our culture that drive the unsustainable, unsatisfying, and unfair social and economic machines that dominate our lives. First, our collective model of the way the world works cannot cope with the complexity of today’s highly connected, high-speed reality. Second, our understanding of human behavior is rooted in this outdated model. Driven by the old guard, sustainability has become little more than a fashionable idea. As a result, both business and government are following the wrong path, by applying temporary, less unsustainable solutions that will fail to leave future generations in better shape. To shift the pendulum, they reframe to “being and caring”, as opposed to “having and needing”, rooted in the beauty of complexity and arguing for the transformative cultural shift that we can make based on our collective wisdom and lived experiences. Then, the authors sketch out the road to a flourishing future, a change in our consumption and a new approach to understanding and acting. Ehrenfeld and Hoffman say it is imperative to pick something other than growth to sustain, because growth is, ultimately, a measure of quantity; they suggest instead a measure of quality. For them, that something is flourishing — a measure of the fullness of life, not some material metric. Flourishing, as the book of the same title proposes, comes when one can say that all of life’s cares are being attended to — when every human being is successfully caring for themselves, other humans, and also the non-human world that is vital to our maintenance. [15]

### 4.2 Sustainable Individuals in Software Engineering

If we manage to raise the awareness and then educate and train current and future software developers to maintain balance in their life and practice self-care to the extent that they feel individually sustainable, we might just get there. Or, as Pappas describes a sustainable individual:

“Sustainable individuals are characterized by creating harmony, interconnection, and relatively high levels of self-awareness in their values, thoughts, behaviors, and actions as well as cultivating continued individual growth in their physical (health), emotional, social, philosophical, and intellectual abilities.” [37]

Individual sustainability includes physical but also mental and emotional health, and in many traditions the desired condition for this is expressed by having a calm state of mind, which however, does not equate to being detached or aloof.

“Having a calm or peaceful state of mind doesn’t mean being spaced out or completely empty. Peace of mind or a calm state of mind is rooted in affection and compassion and is sensitive and responsive to others.”  
— Dalai Lama

## 5 RESEARCH AGENDA

This research agenda is compiled of a number of items that build on the preliminary work and significantly expand the related work

in the field. We detail the research objective exploring the use of mindfulness practices in the context of software engineering education and practice, and propose a series of studies and interventions, answering research questions as well as providing outreach to and impact for practitioners, see Fig. 1.

The main research questions are:

- RQ1 How to integrate mindfulness practices effectively into software engineering education and practice in the least intrusive way,
- RQ2 How to measure the effectiveness of such interventions in terms of cognitive abilities, energy levels and self perception, and
- RQ3 How to predict good timing for interventions such that they don't disturb moments of flow but enhance energy levels when needed.

The items are described in order of increasing complexity and as they build on each other. The work packages we are envisioning to explore and answer these questions are as follows:

## 5.1 Empirical data and Narratives

**5.1.1 Data set.** In March, we distributed a preliminary survey for practitioners on preconceived notions about mindfulness interventions, options for such interventions, and how likely they are to use them, see IEEE Software Blog post [38] and linked survey<sup>4</sup> to gather preliminary data as well as potentially interested subjects. This is important to understand beliefs that might prevent effectiveness of the interventions as well as preferences of users that can be accommodated. At project start we will initiate a social media data analysis on these questions to have an empirical foundation.

**5.1.2 Narratives & terminology.** Based on the data and our training in the domains of yoga and mindfulness, we develop narratives with terminology that is likely to be accessible by software engineers who might be predominantly or initially interested in the physical and mental benefits. For example, it is important to explain the benefit of increase in cognitive abilities and enhanced duration of focus, furthermore the increase of neuroplasticity (new neural pathways in the brain, specifically connecting right and left hemisphere more), and thereby improvement of creativity. It is important to denote we are not neglecting or denying the spiritual aspects (cultural appropriation), and proposing to use terminology that is less connotated with it, and to initially skip traditional vedic terminology as it is foreign to them - in order to encourage a wider audience to try out the practices.

“What unites people?  
Armies? Gold? Flags?  
Stories!  
There is nothing in the world  
more powerful than a good story.  
Nothing can stop it. No enemy can defeat it.”  
- Thyrrion (Game of thrones)

<sup>4</sup><https://forms.gle/Xi2jLiMdhntABYGD9>

## 5.2 In-class interventions and workplace interventions

**5.2.1 In-class interventions.** We develop written and illustrated instructions for the existing mini yoga interventions in class (action research). We evaluate the effects of the yoga interventions with students, using a standard survey<sup>5</sup> as well as self reporting (diaries), and optionally biometric tracking. In order to make this evaluation more meaningful, we aim to use the interventions throughout the entire semester, and if possible, beyond that. Given that they only take 5 minutes each, it is reasonable to offer them optionally at the end of the break in the middle of a longer class session, or at the beginning of a remote online session.<sup>6</sup>

**5.2.2 Workplace interventions.** Building on the experience with yoga classes taught at the department, the insights from the in-class interventions can be expanded on the level of weekly workplace interventions. Evaluation includes self report in surveys and a diary as well as work time and code repository meta data, and optionally biometric tracking. Given that this is happening in a research environment, participants are likely to agree to some data collection for this kind of study. Giving participants options to either join a course or to do home practices in their own time, as well as offering several modalities (e.g. breathwork, yoga poses, meditation) makes the study more encompassing but also enriches the data significantly. We also include a control group of regular practitioners that will cease their practice for two weeks and report on the effects.

## 5.3 Card Deck, practitioner toolkit, training framework

**5.3.1 Illustrated Card Deck.** We develop a “Focus Flow” card deck of 5 minute interventions that you can pull out of the stack, and have an instructional video for those 5 minutes available on YouTube<sup>7</sup>. For these, it will be important to use the terminology developed for the *Narratives* such that participants don't get taken aback by vocabulary too far out of their everyday language. Fig. 2 introduces a breathing exercise along with its benefits. Fig. 3 shows an instruction card that we would adapt for such purposes and also mention the benefits of the particular pose. We develop and test both a physical prototype for the cards and implement an app. The app has the advantage of being able to set a mood or get additional audio and video. The physical cards support a break from screen time.

**5.3.2 Practitioner toolkit.** We conduct action research on small-scale interventions in IT companies by means of a short instructional video series. Making it relatable is an important component here — we can learn anything online, but presence makes a difference, so to affect the culture in a company to transition that way, we explore the difference of physical presence of an instructor on site in comparison to self-guided learning. Part of the physical presence part is to establish a space (“relax room”) to do these exercises and whether that is possible or supported by the stakeholders. Several large IT companies have made large investments in such spaces for

<sup>5</sup>Mindful Attention Awareness Scale (MAAS) as baseline survey and exit survey [https://ggsc.berkeley.edu/images/uploads/The\\_Mindful\\_Attention\\_Awareness\\_Scale\\_-\\_Trait\\_\(1\).pdf](https://ggsc.berkeley.edu/images/uploads/The_Mindful_Attention_Awareness_Scale_-_Trait_(1).pdf)

<sup>6</sup>Several colleagues are interested to replicate this in their classes for a larger data set.  
<sup>7</sup>Breathing exercise videos by PI: [https://youtu.be/VWbGYe\\_eUdM](https://youtu.be/VWbGYe_eUdM), <https://youtu.be/L3IDybjAiWQ>

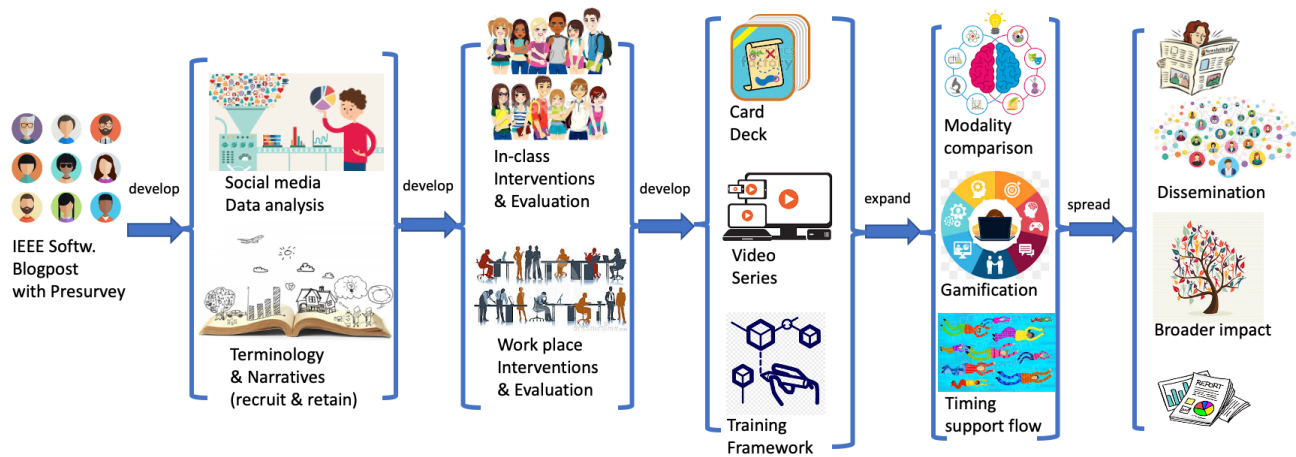


Figure 1: Overview of the proposed research.

increasing the productivity of their employees, e.g. Google, which may be sufficient argumentation grounds for such a space.

**5.3.3 Orchestrating training & practice.** We develop a training framework of scaffolded practices that introduces breathwork, yoga poses, and meditation as either options or combined path towards better physical, mental, and emotional health. This item pulls together the results from earlier work packages into an overall toolkit that can be adapted and tailored for the application scenario (e.g. weaving into software engineering classes at university, or weaving into every day software development practices in a company).

## 5.4 Comparing modalities, gamification, timing for flow

**5.4.1 Comparing modalities.** After developing instruction kits for all three modalities, we compare the effects of breathwork, guided yoga poses, and meditation. Some factors that play into preferences here could include shared versus private offices, personality types, and rigidity of daily schedule. The lowest perceived hurdle is usually associated with practicing deep breathing, because most people can perceive a physical and mental benefit within a matter of seconds, and it only requires slightly intensifying an activity we perform automatically to stay alive.

**5.4.2 Gamification.** The app is further expanded by enhancing the user experience with reward badges, or actual rewards (if possible and desired in company), as well as challenges that users can decide to participate in (e.g. a 30-day daily meditation streak). This may attract a wider user circle or increase retention of participants if the interventions are only individual, remote or online.

## 5.5 Timing and Flow.

Lastly, there is the question of how to facilitate such interventions in a company without interrupting flow and productive thinking processes, as interrupting flow [12] would instead lead to more stress [32]. Ioannou [28] has explored this for probabilistic repetitive project scheduling, but software development is much more complex, whereas we focus on how to sense and how to measure

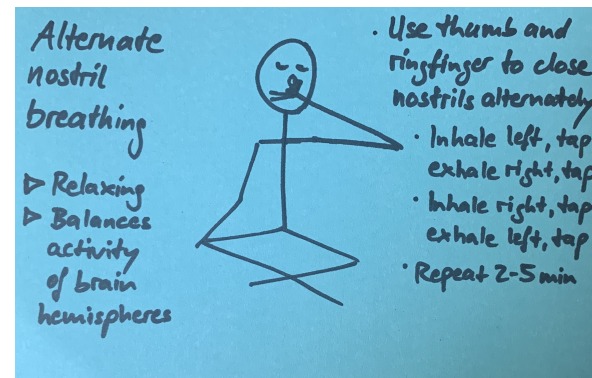


Figure 2: Breathing exercise with associated benefits.

indicators for that. Beck et al. [3] use sensors to measure sitting time. We explore how to judge whether someone who is currently not vigorously tapping on their keyboard is actively thinking or actually in need of a reviving break. Candidate building blocks for a solution on when breaks are needed are sitting time in combination with keyboard activity and eye tracking, as well as AI predictions.

## 6 DISCUSSION

**Responsibility:** There is a legitimate question about how much it is the job of software engineering education to teach about self-care and balance in life. One could argue that it is the individual's responsibility, and that we are interfering with their agency. However, we also argue in other places that our students should be trained in giving presentations and public speaking, because that is a necessary skill for a successful long-term career [1]. Consequently, mitigating the risk of burn out by preparing them with a small set of self-care methods and tools gives them starting grounds they can choose to cultivate further (or not).

**Feasibility:** Prioritization of perceived secondary skills, formerly known as soft skills, in comparison to perceived primary skills of



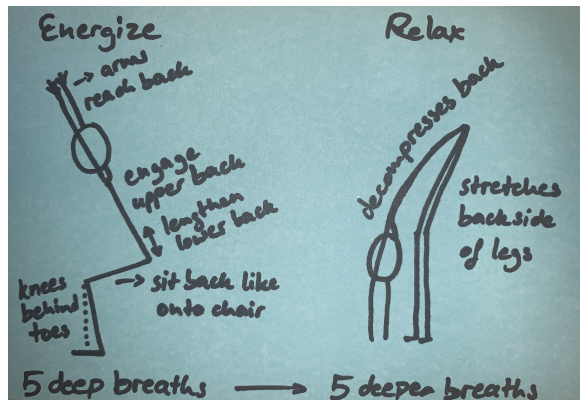


Figure 3: Yoga card that explains the poses “chair” and “forward fold”.

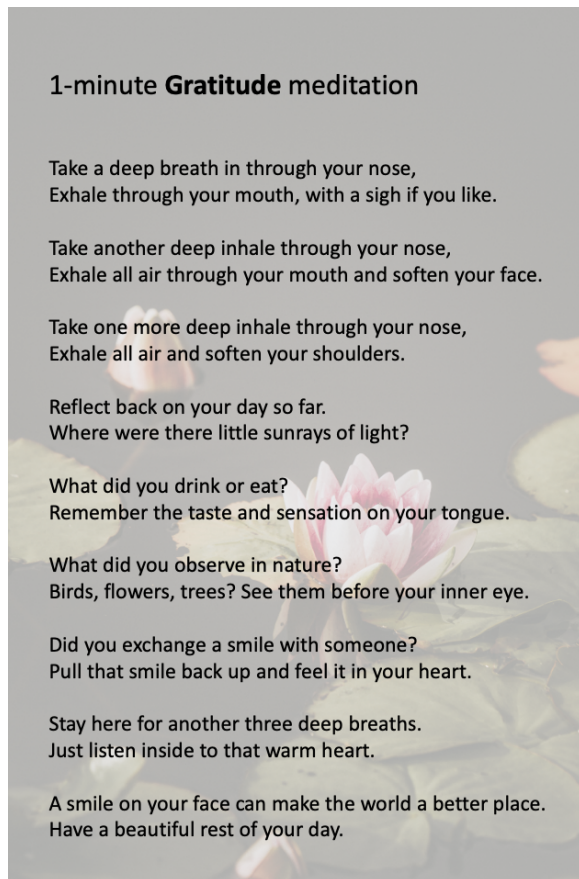


Figure 4: Sample One Minute Meditation Script, script by the author, background photo by Annie Spratt on Unsplash.

a software engineer (designing, coding, testing, maintaining) has been argued in software engineering education research for a long time [18, 20]. Similar to writing, presentation, and communication skills, the prioritization has to be made in balance with the business

objectives an employee has signed up for when they decided on their workplace. Is it feasible for us to convince companies to try out this approach? Most companies do have offers for their employees to bring balance to their work life, and we argue that being brought to the table by a software engineering researcher who happens to be a certified yoga teacher might increase chances of successful recruitment and retention for these interventions.

*Mindset:* What about really conservative engineers who have no interest whatsoever in bending over backwards in order to supposedly improve their creativity? Choosing the right terminology is crucial when introducing these practices. We therefore are developing a set of narratives that use vocabulary non-traditional user groups of yoga practices might potentially be more open to. In other words, I can talk about oxygenation of the body and neuroplasticity to explain the benefits of certain breathing exercises without any of the traditional historic background or terminology of the yogic disciplines.

*Culture:* In shared office getting up might feel disruptive and/or embarrassing. However, here the different modalities of the interventions allow the user to choose a short series of stretches (standing up or sitting in the office chair), a guided meditation they can listen to on headphones, or breathing exercises that will be hardly audible. Additionally, diversity in our profession suffers because many are not attracted to the kind of culture we have in a lot of software businesses, so putting emphasis on developing better self care in the office culture could improve gender and other balances. According to Capretz [10], organizations would benefit from a conscious attempt to diversify the styles or personalities of their software engineers because the strongest teams have the most diverse perspectives. Last but not least, in other countries and cultures, it is fairly common to conduct self-care practices in public, e.g. Tai Chi in China, and similar actions have been taken to increase exercise at the workplace there [30] but also in central Europe [3].

*Offline and outdoor time:* Some of the items in the research agenda, like YouTube videos for interventions, clearly up the online time as opposed to decreasing it, which would be an equally important factor for well-being [50]. However, once stretching or breathing or meditation habits have been cultivated over a period of time, the developer can easily choose to practice outside, taking a little break in fresh air. Taking a break inside or outside makes a significant difference [31], so that contributes to the benefits of the practices.

*Motivation:* Intrinsic motivation decreases the risk of burnout [43, 51] and performing exercises that help reconnect to our inner sense of purpose strengthens intrinsic motivation, therefore the proposed interventions are likely to help prevent burnout not only in terms of achieving balance and individual sustainability but also in reconnecting to our sense of purpose and intrinsic motivation which, in turn, increases goal orientation [51].

## 7 CONCLUSION

To build a more sustainable, equitable and democratic world, we need an empowered, connected and durable movement of citizens [26, p. 1]. Empowered citizens need to be able to care for themselves. In this paper, we made a case for exploring the area of sustaining individual sustainability in terms of physical, mental and emotional health for software engineers — using methods that have been successfully employed by people in many countries.

According to the precautionary principle, this research also promises to help with the danger of unsustainable practices propagating from software developers into their systems. More short-term, it can help to decrease the perceived stress in software engineers, or reduce the likelihood of Depression and Anxiety Disorders that has been observed for computer workers. All in all, this research has the potential to contribute to the third Sustainable Development Goal “ensure health and well-being for all” [21].

In [14], Ehrenfeld calls for products designed to enable people to care for themselves and others. The methods of breathing exercises, movement exercises, and meditation contribute to exactly that, and integrating self-care practice as software professionals can help us get closer towards the vision of a flourishing world.

“Within you, there is a stillness and a sanctuary to which you can retreat at anytime and be yourself.” — Hermann Hesse, Siddhartha

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