



Contemplative Neuroscience as a Gateway to Mindfulness: Findings from an Educationally Framed Teacher Learning Program

Oren Ergas¹ · Linor L. Hadar¹ · Noa Albelda² · Nava Levit-Binnun²

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Abstract

A growing number of publications have been exploring the possible effects of mindfulness-based interventions on teachers' well-being and their professional lives. Notwithstanding promising results in this domain, this paper identifies some difficulties involved in introducing teachers to mindfulness and proposes that there may be a need to develop alternative routes by which to expose more teachers to experiences of mindfulness. We report on a mixed method study of a 5-week teacher learning program implemented in an Israeli middle school with 30 teachers, 28 of which were females, with an age range of 29–55. The program was designed to invite teachers into initial experiences with mindfulness without formally engaging in mindfulness practice but rather based on studying education-relevant brain theory through a contemplative pedagogical approach. Outcomes were analyzed quantitatively by comparing collaborative concept maps created by the participants before and after undergoing the program, and qualitatively by analyzing themes extracted from the participants' discourse. Findings show that the program (a) mobilized teachers from fixed to growth mindsets in regard to their role as educators as reflected in a significant increase in teachers' beliefs that basic brain abilities are malleable (as extracted from the concept maps, $p = 0.004$), (b) offered them initial experiences of mindfulness, and (c) possibly opened them to consider more direct approaches to mindfulness practice that are offered in mindfulness-based interventions.

Keywords Mindfulness · Education · Teacher development · Neuroscience · Contemplative pedagogy

Introduction

The field of mindfulness-based interventions (MBIs) in educational settings has been developing in diverse ways in the past decade as is evident in a number of published meta-analyses and reviews (Felver et al. 2015; Lomas et al. 2017; Meiklejohn et al. 2012; Schonert-Reichl and Roeser 2016; Zenner et al. 2014). The rationale for offering MBIs for teachers has often been grounded in the combination of three evidence-based claims: (a) teaching is one of the most

stressful professions (Kyriacou 2001; Lomas et al. 2017; Skinner and Beers 2016), (b) stress can have adverse effects on teachers' personal and professional lives (Crain et al. 2016; Jennings et al. 2011; Lomas et al. 2017; Roeser et al. 2013; Taylor et al. 2016), and (c) evidence of the effects of mindfulness on stress reduction (Grossman et al. 2004; Kabat-Zinn 2005). Indeed, empirical studies of MBIs with teachers have found improved strategies of coping with stress and burnout (Flook et al. 2013), a reduction in negative appraisal (Taylor et al. 2016), improved resilience (Meiklejohn et al. 2012; Skinner and Beers 2016), as well as positive effects on classroom management and relationships with students (Jennings et al. 2011). Lomas et al. (2017) conducted a systematic review of MBIs for educators and concluded that "given the largely promising results... it would be ideal to see MBIs being offered in all teacher training courses and in all educational environments" (p. 139).

Against the backdrop of these results, Lomas et al. (2017) also observed that the exposure of teachers to mindfulness may require program designs that are more diverse than currently offered. There are some indications that it is not always

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✉ Oren Ergas
oren.ergas@mail.huji.ac.il

¹ Beit Berl College, Kfar Saba, Israel

² The Sagol Center for Brain and Mind, The Baruch Ivcher School of Psychology, The Interdisciplinary Center, Herzliya, Israel

easy to recruit teachers for MBIs. Gold et al. (2010), for example, recruited only nine teachers from six schools despite having offered a presentation on mindfulness and its effects. Similarly, Ancona and Mendelson (2014) described quite an effortful recruitment process. Difficulties in recruitment might not be surprising when it comes to interventions, such as MBIs, which require a significant commitment to practice. This becomes even more problematic in the context of teachers' lives that are often hectic, and the notion of spending time on stress reduction may feel counterintuitive to them.

Developers of MBIs for teachers have articulated the link between teaching and mindfulness based on considering occupational health, social-emotional skills (Ancona and Mendelson 2014; Jennings et al. 2011; Meiklejohn et al. 2012), and "habits of mind," which enhance the ability to engage effectively with students (Roeser et al. 2012). Many of these frameworks of linking mindfulness and teaching have indeed been helpful and led to effective implementations of teacher MBIs. However, some teachers may prefer programs that are more "hands-on," skills or information-oriented, rather than programs such as MBIs that carry a deep reflective orientation (Hadar et al. 2013). This may stem from personal inclinations, a fear of the kind of commitment to self-change that might be associated with MBIs, or from a tangible sense of lacking curricular-pedagogical skills.

In addition, some of the difficulties involved in introducing mindfulness to the general public may also apply to teachers. These can include uninformed dispositions concerning mindfulness, such as its possible association with spirituality/religion, and/or self-conceptions of being "too antsy for meditation." Importantly, Lomas et al. (2017) pointed to the fact that MBIs are often derivatives of MBSR and MBCT, which stem from a clinical-therapeutic orientation. This may resonate with the acknowledgement of teacher-stress, but it might be perceived as too loosely tied to the professional aspects of teaching concerned with disciplinary knowledge and skills, or to teachers' conceptions of themselves as educators. Indeed, it has been observed that some conceptualizations of teacher professional learning fail to address the ways in which learning is embedded in their professional lives (Opfer and Pedder 2011; Zohar 2006), and professional learning programs (even those showing positive impact) are not always found to be relevant to all teachers (Avalos 2011).

We suggest that while it is evident that MBIs may be suitable and beneficial to some teachers, it is possible that their format and framing target a specific population within this group. There may be teachers who are less inclined toward engaging in an MBI yet may still benefit from a different kind of exposure to mindfulness, and perhaps one that is more clearly embedded in an educational rather than clinical context. Based on these observations, we set out to

explore whether an educationally oriented program, that integrates teaching relevant subject matter with a subtle introduction to mindfulness, might be an effective way to embed mindfulness in a broader educationally relevant context. We designed a teacher learning program focused on brain plasticity and human development in education, which is based on a contemplative pedagogical approach. We hypothesized that this would broaden teachers' horizons as to their profession on the one hand, and open them to the possibilities of mindfulness practice on the other hand. Specifically, we attended to the following research questions: (a) Will the contemplative pedagogical approach we implemented serve as a gateway to mindfulness experiences? (b) How well will these pedagogical practices be accepted by the teachers? (c) In what ways will the program change teachers' conceptions of the brain? (d) In what ways will the teachers' discourse change during the program?

Method

Participants

Participants included 30 teachers (28 females, 2 males; age range 29–55; Jewish ethnicity) from a large urban middle school in central Israel. The program was offered to the school for free as a pilot program. The sessions took place during the weekly teacher meeting. On average, 87% of the teachers attended each meeting.

Procedure

Following the considerations described above, our program "brain plasticity and human development for teachers" aimed to provide teachers with: (a) teacher-relevant curricular content based on brain theory, (b) exposure to mindfulness experiences in a less direct, and friendly way; nevertheless one that remains loyal to fundamental principles of contemplative practice. Two orientations provided us with a way of integrating these two elements into a coherent curricular-pedagogical approach: (a) previous evidence, which demonstrated that the field of neuroscience may significantly contribute to teachers' personal and professional identities (Blackwell et al. 2007; Dubinsky 2010). (b) Findings showing that first-person methods of inquiry in the teaching of neuroscience were found to be a feasible pedagogical approach in higher education, which enhanced the learning of complex brain-theory concepts (Levit-Binnun and Tarrasch 2014).

The curricular design of our program was based on Davidson and Begley's (2012) theory of the emotional styles of the brain, which lends itself to a methodical approach to understanding the brain in social contexts, such as schools. According to this theory, the way we think, feel, and react to

the world is determined by six dimensions: resilience, outlook, attention, self-awareness, social intuition, and sensitivity to context. Each dimension is linked to the functioning of specific brain circuits (e.g., resilience depends on the strength of neural connections between the prefrontal cortex and the amygdala). Based on training, one can affect one's own brain and "mobilize" oneself over a dimension's continuum toward improved balance. Davidson's theory served as a main framework for introducing teachers to the potential of brain plasticity and to individual differences as expressed in brain circuitry.

Each session (except session five) included four components: (a) frontal lecturing focused on explanations of basic brain concepts (e.g., neurons, networks) and on one or two of Davidson's dimensions (see supplement S1 for details on the program's curriculum), (b) contemplative brain investigations (CBIs), (c) inquiry process (IP), and (d) sharing insights from previous sessions. We turn to explain CBIs and IPs as the core pedagogical-curricular approach in this program, which combines neuroscience and contemplation.

CBIs are scientific first-person introspective research methods (Levit-Binnun and Tarrasch 2014; Varela and Shear 1999) that are associated with the study of concepts within brain theory. Essentially, as other contemplative pedagogies, they can be viewed as brief (1 to 5 min) contemplative practices per se; however, they are framed as aiming at inquiring our subjective experience for educational and/or scientific purposes (Ergas 2017a). In our program, they were taught as follows:

Theoretical preparation: explanations of specific brain theory concepts always preceded CBIs in order to provide participants with a clear understanding of the exact field that they are to investigate.

Imagining the setting: participants were asked to literally "wear white lab coats" and imagine that they are scientists; however, unlike conventional scientists who usually study external objects/events, they will be examining their own first-person experience.

Framing instructions based on brain terminology: no reference to any clinical/therapeutic (e.g., stress reduction) and/or religious/spiritual contexts (e.g., Buddhism) was made while CBIs were taught. Rather, the terms applied were associated with concepts from brain theory. For example, during CBI 2a (see supplement S2) called "Cleaning the microscope lens focusing exercise", participants were told that the focusing network is our investigation tool. It is like a microscope for scientists. Participants were instructed to choose an object and focus on it (e.g., the breath, a certain place in the room). If they felt that their attention had wandered, they were to gently bring it back to the chosen object. They were also asked to note whether this was easy or difficult for them. As evident, these instructions very much resemble a focused

attention mindfulness practice (Slagter et al. 2011), yet here, it is framed as an experiential pedagogy that supports the understanding of the brain's attentional networks. Similarly, CBI 4b "Investigation of the default mode network" requires that participants simply sit and do nothing but note what their minds are up to for 3 min. This could be viewed as *Zen shikantaza* (i.e., "just sitting"), yet here it is discussed in terms of the brain's default mode network (Raichle and Snyder 2007).

Reporting findings: participants were asked to report "findings from their observations" in a non-judgmental scientific way (as in filling out a lab report): "when X happened I noticed that Y happened".

After each CBI, participants engaged in a 5- to 10-min inquiry process (IP) implemented by the facilitator. The process comprised of a series of questions posed to one individual at a time. The intention in IPs was to (a) help relate between participants' individual experiences and the brain concepts discussed, (b) assist participants in conceptualizing and understanding their first-person experiences, (c) support participants' curious beginner's mind as well as their willingness to accept whatever they find non-judgmentally, (d) support a group atmosphere as a stage for mutual respect and scientific investigation (and not as an arena for group dynamics), and (e) demonstrate that brain mechanisms are generic, but our individual brains will each have their particular ways of functioning, which yield the individual differences that participants experience during CBIs.

The program consisted of five sessions (2–3 weeks apart) delivered by a trained neuroscientist who is also a mindfulness teacher. The sessions took place at school between January and March 2016. Each session lasted an average of 91 min (see Table 1) and was audio-recorded at the consent of the participants. Overall, the intervention included 13 CBIs (dispersed 1, 4, 3, 4, in the course of the first four sessions—see supplement S2). Table 1 shows the duration of each of the four components mentioned above:

Measures

Documentation of the Sessions

We observed all five sessions and documented all activities and conversations. We also recorded and transcribed all of the sessions.

Teachers' Reflective Writing

In the final session, teachers wrote reflectively about their experience. We asked them to reflect on the applicability of the program responding to the following questions: What will

Table 1 Program overview—components and duration

	Lecture	Sharing insights	CBIs	IP	Overall/meeting length
1	42 min	–	4 min	12 min	58/96 min*
2	26 min	14 min	17 min	16 min	73/88 min
3	40 min	21 min	10 min	9 min	80/81 min
4	37 min	25 min	9 min	7 min	78/86 min
5	6 min	59 min	–	–	65/105 min*
Total	151 min	119 min	40 min	44 min	354/456 min

*During the first and fifth sessions, time was dedicated to technical issues and to brain concept mapping

I do with these ideas after the program? And was there anything that I felt to be missing from the program?

Collaborative Concept Mapping

Concept maps are a graphic-organizing technique designed to help individuals explore their knowledge or understanding of topics that are highly elusive (Novak and Gowin 1984). They are metacognitive tools used to illuminate one's thinking (Ritchhart et al. 2009). As a data collection method, concept mapping enables researchers to uncover nascent ideas. With repeated application, this tool enables to chart development over time. In our study, we used concept mapping twice, in the first and the last sessions. We purposely used a general prompt, attempting to support rather than inhibit teachers' responses. We started the first session with the prompt: "I would like you to think and map your associations to the word 'brain'". We ended the last session with a similar prompt. In both incidences, teachers were given a few minutes to think about their own associations, and thereafter, we engaged in a collaborative discussion in which each teacher added her/his associations into one collaborative concept map that was created on the headboard. When a new association was brought up, it was added to the collective map. The collaborative concept map was photographed (see supplement S3). For triangulation purposes, the collaborative concept mapping procedure was carefully documented by one of the researchers. When an association that was already raised by another teacher was brought up again, it was registered to enable us to investigate the frequency of identical responses. This procedure was recorded and then transcribed.

Data Analyses

We applied a different research orientation for each of the research questions, utilizing the data in different ways as detailed below. The data analysis methods are presented in reference to each research question:

Can CBIs Serve as a Gateway to Mindfulness?

Using a qualitative approach to the data, we focused on the session transcriptions. Our approach to the analysis of the session transcriptions was informed by the sociocultural discourse analysis tradition (Mercer 2007, 2010). This approach involves a close examination of talk in its social and cultural context in order to examine how shared understandings are developed (Mercer 2008, 2010). In the qualitative form of sociocultural discourse analysis, researchers mainly focus on processes, and the findings are usually illustrated by selected extracts of transcribed talk to which researchers add a commentary. Our analysis of the session transcriptions focused on the content of the conversation. Much research on teacher professional learning relies on reports after the fact, including interviews (e.g., Meirink et al. 2007; Warren-Little 2002) or surveys (e.g., McLaughlin and Talbert 2006; Talbert and McLaughlin 2002). This study expands these methodologies to reveal what teachers say in such contexts. Understanding how a particular activity supports learning requires looking systematically at events and activities for specific evidence (Hadar and Brody 2016).

The session transcriptions enabled us to explore the teachers' CBIs experience as evident in their talk. The data analysis method was based on a dual procedure: bottom-up—from the transcriptions to conceptions of mindfulness practice, and top-down—from preproposed mindfulness-associated categories, which reflect the experience of practice derived from the literature (Kabat-Zinn 2005; Yates et al. 2015) and back to the transcriptions. We analyzed the session transcriptions using an inductive approach (Corbin and Strauss 2008) to identify evidence that CBIs invoke experiences that can be clearly associated with experiences of mindfulness practice per se (bottom up approach). To obtain trustworthiness, several excerpts were highlighted and interpreted individually by two authors and then compared and discussed. This resulted in the deriving of two robust categories that are well-documented in mindfulness literature (top-down approach): cultivation of awareness/attention and mindfulness of the body. Other mindfulness-associated categories (e.g., compassion, beginner's mind (Baer 2015; Kabat-Zinn 2005; Suzuki 1999) were not as evident;

nevertheless, some were identified in the data; hence, we provide specific reference to these aspects within the presentation of the two main categories.

How Well Were CBIs Received by Teachers?

We read through the teachers' reflections to investigate their acceptance of CBIs. The analysis of this data was based on an inductive approach (Corbin and Strauss 2008) using a method by which each researcher individually abstracted preliminary categories in the teacher responses. We then compared notes, agreed on a list of themes, and counted the number of responses corresponding with each theme.

In What Ways Has the Program Changed Teachers' Conceptions of the Brain?

We documented changes by analyzing the collaborative concept maps. We used a mixed method approach in which we first qualitatively coded the maps and then applied basic descriptive statistics to show changes in teachers' conceptions over time. Since there were no existing analytic scoring schemes available, we employed an inductive coding approach (Corbin and Strauss 2008). This allowed us to best represent all of the data and to articulate a frame for understanding teachers' conceptions of the brain. We first aggregated all teacher responses in both sessions ($n = 115$). This provided us with a list of terms, which participants associate with the brain. Each researcher then attempted to categorize these responses individually. Again, this was based on both a bottom-up approach stemming from the raw data, and a top-down approach based on studies focused on teachers' understandings of the brain (Dekker et al. 2012). We then discussed our individual categorization and arrived at an intersubjective agreement on four types of responses. At this stage, one author categorized all responses according to the four types of responses, being blind to the information regarding the concept map session in which the response occurred. Trustworthiness was obtained by a method in which each researcher cross-checked the matching between each type of response and the concept map representation of this response, yielding 95% agreement. Disagreements were solved and matching of each response to the first or the second concept map session took place at this stage. Out of 115 responses in both sessions, 56 were brought up in the first and 59 were provided in the second session.

In What Ways Did the Teachers' Discourse Change During the Program?

To identify how teachers' discourse developed throughout the program, we analyzed the session transcriptions of the five sessions. The transcriptions were analyzed using an inductive

approach (Corbin and Strauss 2008), informed by the socio-cultural discourse analysis tradition (Mercer 2007, 2010). This analysis can show teachers' understanding development over time (Dudley 2013). Categories that exemplify changes occurring over time were first abstracted by each researcher individually. At a second phase, we compared notes and agreed on a list of shared themes. At a third phase, each researcher was assigned one theme with which she/he scanned all of the session transcriptions to identify representations of that theme. This process resulted in a data matrix which included three themes, and all representations found in the data for each theme divided according to the sessions. This matrix enabled us to follow the changes in two dimensions: a content dimension (in what ways did the teachers' discourse change?) and a temporal dimension (at what session did changes take place?). Trustworthiness was obtained by a method in which each researcher cross-checked the matching between each theme and the discourse representation of this theme.

Results

The findings are presented in reference to each research question:

Can CBIs Serve as a Gateway to Mindfulness?

The categories below demonstrate that teachers' engagement with CBIs were associated with two categories that are clearly linked to mindfulness literature: cultivation of attention/awareness, and mindfulness of the body.

Cultivation of Attention/Awareness

Mindfulness and contemplative practices writ large are fundamentally grounded in practitioners' monitoring, directing, and sustaining attention either through focused attention over a specific chosen object or based on open awareness (Ergas 2017b; Slagter et al. 2011). In CBIs, attention is rendered both as an internal scientific device (internal microscope) that requires cultivation (or polishing of the lens) and as the tool by which brain concepts (e.g., sensory experience, arousal) are investigated/experienced within one's first-person experience. We found that participants' struggles and successes with engaging attention voluntarily within CBIs were very similar to those that are described in MBSR, MBCT, and contemplative practice literature (Kabat-Zinn 2005; Segal et al. 2002; Wallace 1999; Yates et al. 2015). The following excerpts demonstrate these processes of attention/awareness cultivation as they unfolded in two CBIs.

In session no.2 (CBI 2b—examining differences between focusing on the breath before and after an arousal-inducing

bodily exercise), we found the following responses during the IP:

P1: During the second time [after arousal-inducing exercise] you [facilitator] didn't speak and in the first time you spoke throughout, so in the first time that bothered me a little.

P2: In the second time, I was a little more focused on the breaths.

P3: The voices [from outside] bothered me... in the second time the focus was better.

P4: I was much more focused in the first time... in the second time I found it harder to focus and I yawned all the time.

The above demonstrates coarse observations of participants in regard to the quality of their attention. It also reflects individual differences in terms of preferences for instruction and the effects of an arousal-inducing exercise on attention. Such observations could easily stem from a conventional introduction of mindfulness practice (Kabat-Zinn 2005; Yates et al. 2015). The following excerpt provides an additional illustration of the cultivation of attention as well as hints of insight:

P5: I noted that when I focused on my breath it started changing. It became something that I am aware of and can control...It started to affect my entire body, and my head ached...I wasn't able to come back to the breath after this.

This quote points to the realization that when we attend to something, especially when it has to do with our own experience, we affect the object of our attention. In this case, this led to an adverse effect (i.e., headache). It points to a common phenomenon of beginning mindfulness practitioners who often express this difficulty when attempting to observe natural breathing (Yates et al. 2015). In an MBSR setting, such a report might suggest a need to discuss ideas such as “right effort,” “detachment,” “letting be”; however, this is where the current program strays from MBIs. This phenomenon remains part of an inquiry of the brain, without getting into “further instructions on how to practice”.

In session no. 2 (CBI 2d—participants focus inward and explore which external and internal stimuli are prioritized by the brain and “magnetize” attention to them), the following IP unfolded:

P1: the voices from outside called my attention.

Facilitator: voices of people?

P1: yes

Facilitator: Was it hard to bring attention back from them?

P1: My attention went back and forth.

P1 uses the passive voice, saying that attention “went back and forth” as if on its own accord. It is possible that bringing back her wandering attention was *her* voluntary act that amounts to the practice of mindfulness when rendered as focused attention (Slagter et al. 2011). Hints of *insight* appear here in her detection of becoming more knowledgeable as to those things that compel us to attend to them, and are difficult for us to control. P2 responded differently:

P2: I didn't hear the voices from outside at all ... I had all kinds of thoughts in my mind and I immediately noted that I was paying attention to both my breathing and the thoughts.

Facilitator: Did you notice what kind of thoughts you were having?

P2: Things that bother me.

Facilitator: Was it hard to bring attention back to the breath?

P2: I couldn't do it. I found it hard to be in either [breath or thoughts].

While P1 struggled with outer stimuli, P2 struggled with inner stimuli in the form of thoughts, and perhaps mind wandering. She reports attending to both at once, which may for example connote with Yates et al. (2015) whose account of mindfulness practice suggests a constant tradeoff between attention (as the focus of experience) and awareness (as all the peripheral experiences around it). P2 acknowledges the pull of thoughts as winning over attention—a most familiar experience of practicing mindfulness (Kabat-Zinn 2005).

Mindfulness of the Body

The body as an anchor to the present moment is central to conceptions of mindfulness within the *Satipatthana Sutta*, within MBSR courses that begin with the “body scan” (Kabat-Zinn 2005) and in some neuroscience accounts of mindfulness practice (Kerr et al. 2013). CBIs varied in terms of the extent to which they required attending to the body; nevertheless, many of the facilitator's questions were directly geared toward raising participants' awareness to their bodies, in order to unfold the complexity of brain functioning. The category mindfulness of the body has to do with participants' acknowledging, appreciating, or noting their bodies in ways that transgress day-to-day perception. These include acknowledging the role of embodiment in perception (i.e., embodied reactions to stimuli), bodily changes throughout a CBI and novel embodied experiences as a consequence of CBIs. In session no. 3 (CBI 3b—participants explored embodied reactions to a set of visual and auditory stimuli, such as baby-crying), the following IP took place:

P1: I noted that all my reactions pass through my chest.
 Facilitator: Always with the same intensity and in the same spot?
 P1: Yes.
 P2: I experienced suffocation when I heard the baby crying and when I saw the image of the baby.
 P3: I felt the louder noises in my head.
 Facilitator: Where exactly?
 P3: Over here [pointing to her head].
 P4: When I saw the baby with the problem in the eye, I felt pain in my own eye...
 P5: I felt almost everything in my abdomen...when I saw that baby I felt shivers; like an arrow in the abdomen.
 P6: When the siren was heard, I felt danger.
 Facilitator: Danger as a thought? Did you also notice it somewhere in your body?
 P6: No, everything was in the head; in the brain...then I felt scared, and then with the cockroach it was like “yuch.”
 Facilitator: Ok, so all these are verbal descriptions ... Did you notice something that accompanied these words in your body as well?
 P6: No. It was all verbal.

This CBI invokes the inquisitiveness that we find in practices, such as a *body scan* in which participants are instructed to identify the location of sensations and distinguish between their intensity and nature (Kabat-Zinn 2005). In the above exchanges, we see that in the majority of the cases, participants experience embodied aspects of perception and are able to report on them with varying degrees of awareness (compare P1 and P6). Notably, in body scans, instructions often aim at cultivating an ability to distinguish between the preconceptual level of sensations and the interpretations and labels that we often lay on top of them (Kabat-Zinn 2005). The facilitator’s exchange with P6 externalizes this progression. P6 uses concepts to describe her reactions, and the facilitator invites her to further explore whether her body participates in the process as well.

In session no. 4 (CBI 4c—the facilitator placed her hand in a bag of ice and asked the participants to observe their embodied reactions):

P1: My right hand felt cold. Like yours. Amazing.
 P2: I felt sorry for you.
 Facilitator: Where did you feel that?
 P2: In my heart.
 P3: From the moment you said that you’re about to put your hand in the ice, I got goose bumps all over my body.
 P4: I didn’t feel a thing. It felt more like kind of a joke.

P1 continues the above excerpt as she acknowledges embodied perception. However, the word “amazing” points to an

experience of insight. P2 expresses empathy or perhaps compassion that appears in some contemporary renditions as integrated into the practice of mindfulness (Schonert-Reichl and Roeser 2016). P3 seems to become mindful of how our mere imagination can induce bodily changes, and P4 reveals somewhat of the same phenomenon, yet in reverse—if we do *not* take a situation seriously, we can become apathetic.

In sum, participants who engaged in CBIs reported on experiences that are similar to those of beginner mindfulness practitioners. Furthermore, CBIs cultivated an awareness to bodily reactions toward stimuli; an important aspect of the practice of mindfulness. On occasion, we also found additional experiences that are associated with mindfulness, including insight and compassion that emerged through engaging with CBIs.

How Well Were CBIs Accepted?

In response to our general questions: “What will I do with these ideas after the program?” and “what was missing from the program?” we found several teacher reflections that directly addressed the contemplative orientation of the program (CBIs), which formed the overarching category. We found three themes (Table 2).

Aside from one response: “I don’t think I’m going to try this myself,” these findings indicate a positive reception of the CBIs. Though mindfulness was not taught directly, nor was there an intention to motivate the teachers to try contemplative pedagogies with their students, these reflections show that teachers found the practices to be valuable, and one teacher had actually implemented them in her class.

In What Ways Has the Program Changed Teachers’ Conceptions of the Brain?

The analysis of the concept maps resulted in four types of responses (Table 3):

Table 2 Teacher reflections on the programs contemplative component

Category	Examples	Number of responses
Expressions of a need for more practice in the program	I thought we could use some more practices, I would have liked to have more self-work in the program.	5
Interest in personal contemplative practice	It seems helpful to stop the routine for 10–15 min a day and attend to the breath.	6
Interest in applying contemplative practices in the classroom.	I’d really like to try some attentional training in my classroom. I do the breathing practice in my classroom when the kids are restless, to teach them to regulate their emotions.	12

Table 3 Teachers conceptions of the brain

Category	Examples	Number of occurrences
Commonplace notions: What people usually think when the word brain is brought up (Dekker et al. 2012; Pickering and Howard-Jones 2007).	Mystery, we use 15% of the brain, left, and right hemisphere	27
Malleability: The belief that abilities, like intelligence, are not fixed and can change throughout life (Davidson and Begley 2012; Dweck 2006).	Development of ability, cognitive development, change throughout life	29
Abilities: what the brain is responsible for	Thinking abilities, attention, perception, and intelligence	38
Functionality: how the brain functions	Connections, neurotransmitters, and chemical reactions	21

Based on a quantitative analysis of changes in teachers' understanding of the brain, we found that while in the first session, teachers mostly represented commonplace notions and abilities; in the second concept mapping session, they emphasized the malleable nature of the brain and its functionality (Fig. 1).

The changes in teachers' understanding from the first (session one) to the second concept mapping (session five) are significant in all four categories. Chi-square analysis shows a significant reduction in the teachers' commonplace responses (chi-square (1) = 9.07, $p = 0.004$, $\eta^2 = 0.06$), and a significant reduction in their reference to the abilities of the brain (chi-square (1) = 16.51, $p < 0.000$, $\eta^2 = 0.14$). Our analysis shows a significant increase in the teachers' beliefs that basic brain abilities are malleable (chi-square (1) = 9.073, $p = 0.004$, $\eta^2 = 0.08$) and an increase in their reference to the

brain's functionality (chi-square (1) = 5.51, $p = 0.034$, $\eta^2 = 0.04$).

Qualitative analysis of teachers' responses reasserts the overall transition from the categories of common notions and abilities to the categories of malleability and functionality. In the first session, we see that teachers' responses are bound with their professional identity as they refer to what the brain does, e.g., attention and intelligence, which tends to reflect a fragmented notion of the brain as inferred also from responses from the category of common notions, e.g., left and right hemispheres, use of less than 15% of the brain. Responses from session one are tied together with an overall view of the brain as a fixed attribute, e.g., responsible for students' intelligence, our landlord.

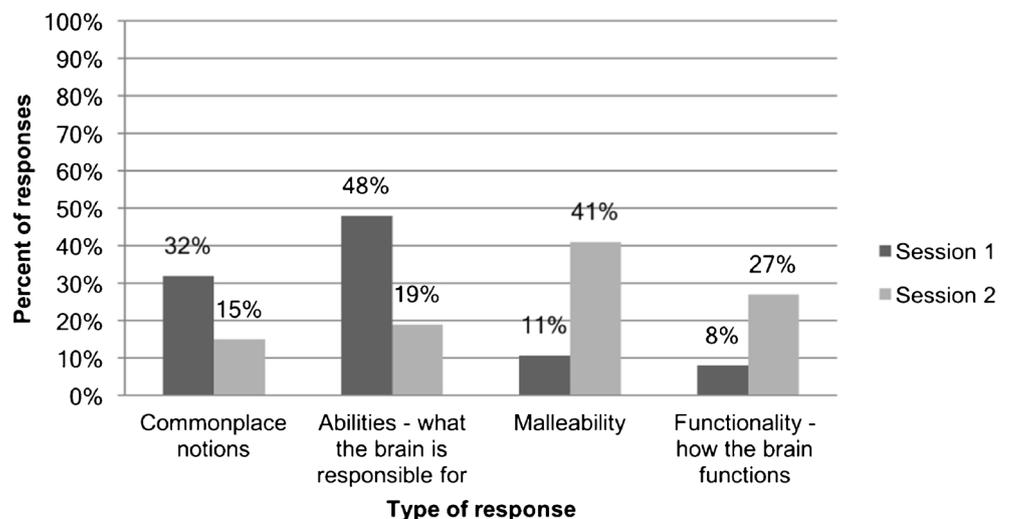
In contrast, teachers' responses in the second session emphasized the integration of brain functionality, e.g., everything is influenced by everything and everything influences everything; it is a system, a network of multiple connections. We also found a transition toward an understanding of the brain's malleable nature, e.g., changes throughout the years; it is flexible.

This overall progression reveals a growing complexity in teachers' understanding of human behavior. The group's understanding of the brain seemed to have shifted from understanding it as a static object that determines who we are, to viewing it as a process that is affected constantly by external and internal stimuli. Furthermore, its abilities are directly tied to how it functions.

In What Ways Did the Teachers' Discourse Change During the Program?

Three themes pointing to the way teachers' discourse has changed throughout the intervention emerged: change from fixed to malleable mindset, perspective taking, and change from external to internal locus of control.

Fig. 1 Teachers' type of responses in the first and second concept map session



Changes from a Fixed to a Malleable Mindset

Similar to the concept mapping sessions, we found that teachers' discourse also reflected a development from a fixed to a malleable mindset. We detected a shift from statements that depict the brain as a fixed set of functions to statements that reflect an understanding of the brain as a constantly changing and developing organ. For example, in session no. 1, while talking about the brain, one teacher claimed that "we have this engine; it sets our ability for success. It functions as a measure for our successes and our intelligence". Already, in the second session after the first brain exercise, we saw how teachers began to realize the dynamic nature of our brains:

P1: Our brain adjusts itself at a certain level. For example, a mother sets her mind to hear her baby crying. While sleeping, she will not wake up from other noises. We have a certain ability to adjust our brain in order to know what to respond to.

P2: Does this mean that something can change in my brain as a result of my activities throughout life?

Session four brought further change. While in previous sessions the teachers' understandings reflected development of themselves as individuals, in session four, the discourse shifted to include their professional self:

P1: I think that this is applicable in classroom situations...if the children were aware of how things can change, and that it is in their power to change them, then maybe things would look different...I am like this now, but if I train myself effectively I can really change...and it is important that you believe this and do whatever you can in order to improve.

P2: Before we take it to our students and explain what we know...it is important that we, as a team of teachers, think differently...we can push a student and help him achieve more...What mostly counts is what we believe, what messages we transfer and what we model for them in our behavior.

This wide perspective, which goes beyond oneself to include teachers' professional self, a change in teachers' mindsets, is one of the most dominant changes that we identified.

Perspective Taking Abilities

Toward the end of the program, following session four (which specifically focused on the social brain), teachers started to realize and accept that other individuals may have reactions, perceptions, and behaviors which are different from their own, because they are "wired" differently. This acceptance also led

to efforts on teachers' behalf to try and understand others' perspectives; most importantly, others with whom they have professional relationships (e.g., students, parents). It also led to the realization that this can be used as a tool to resolve conflicts or to overcome difficulties in dealing with other people in professional situations:

P1: People need to realize that each child's brain is special. It works differently.

P2: I got a phone call from a student's mother which was very angry and I thought about what you [Facilitator] said and felt how I was working with myself to echo her for a moment, to switch roles with her...my reaction in that phone call changed. It could have turned into a power struggle, and it really helped me finish the call with a feeling of mutual concern...usually I think "I don't work for you"... but then I thought, I'll try to... see where she was coming from? why she was talking that way?...my reaction was totally different...from how I would normally react.

Change from External to Internal Locus of Control

We found a shift from considering teachers' and students' abilities and behaviors as governed by the brain in an uncontrollable fashion, to the realization that these processes were controllable and subject to change. Such change enables teachers and students to take charge and assume responsibility for what happens to them. It allows teachers to nurture their students' abilities and guide their behavior in beneficial ways. In session no. 1, teachers regarded the brain as managing them or their students rather than as enabling them to manage themselves:

P1: The brain is our landlord.

P2: Whether we want to or not we tune [our students' brains]...I don't control this process.

P3: Attention and awareness are not something you can control. They are something that is imprinted.

In session two, a change was already evident as there are some references in the teachers' discourse to their ability to influence students and support their development by influencing their brains. This change seemed to stem from the teachers' new understanding of brain plasticity:

P1: ...it [the subject of brain plasticity] opened a new channel of thinking for me. You talked about critical time points [of brain development] - childhood and adolescence - and I was very encouraged by it...In one of the groups I teach in the 9th grade we talked this week about the possibility of transferring some of the students

to a more advanced group [of math studies] and it encouraged me to ‘give it a push forward’...I also told my family over Friday night dinner that there are two critical time points but anyone can open for himself more time points and that’s what’s important here...

Similar references appeared in session five during teachers’ reflections as to how they might apply the content from the workshop in their work at school:

P1:...they come with negativity and they think they will not succeed...They got it when they were children, I don’t know from who...and it stays strong in their brains...they don’t even try to change...we have to tell them that it is possible.

Discussion

We designed our program in an attempt to respond to some of the difficulties involved in the delivery of MBIs to teachers by developing an approach that specifically caters to educators (Lomas et al. 2017; Roeser et al. 2012). The intention of our program was to (a) contribute to teachers’ professional learning based on expanding their horizons in the domain of education and human development and (b) offer teachers who are not necessarily inclined toward standard MBIs, exposure to brief experiences of mindfulness. Our hope was that after this exposure, at least some of the teachers will express interest in further education in mindfulness (e.g., seeking an MBI, seeking to share contemplative practices with their students).

The results of our study suggest that the program has met our goals. We found that teachers were capable of engaging with the CBIs. The educative-scientific setting of the CBIs proved effective in creating curiosity, and the process of inquiry enabled the teachers to articulate their first-person experiences in detail. Our analysis showed that the descriptions of these experiences can be associated with experiences of cultivation of attention/awareness typical to the practice of mindfulness (Kabat-Zinn 2005; Yates et al. 2015). Furthermore, some of the CBIs created a growing awareness of the body’s role in perception, a feature characteristic of mindfulness practice (Varela et al. 1991). The surprise expressed by some participants in some of these cases demonstrated that these may have been significant discoveries for them, especially when this was associated with compassionate responses (as in the case of the facilitator’s placing her hand in a bag of ice).

We find it significant that despite our intentional refraining from practicing mindfulness qua mindfulness, and despite having refrained from asking them to specifically comment on the CBIs in their reflections, some teachers clearly expressed that they would have liked to experience more of

the practice during the program, and some expressed their motivation to try these practices with their students. Interestingly, actual engagement in the 13 CBIs comprised of only eight percent of the program. Our sense was that teachers who are new to the context of contemplation would not be able to handle much more. We preferred to be “on the safe side” and limit contemplation time to ensure that it indeed serves as a gateway to mindfulness and does not bring with it too much of the struggles of formal practice. Teachers’ responses suggest that we might be able to extend contemplation time in future implementations, which may yield even more significant results.

In light of previous accounts (Levit-Binnun and Tarrasch 2014), we suggested that brain theory presented in educative ways and taught based on contemplative pedagogies that are carefully designed to enliven and embody the theory may bear a transformative educational potential. We indeed found that teachers were highly engaged with the content, and that this particular way of teaching brain plasticity can lead to significant insights for teachers in terms of how they understand their role and responsibility. Such shift in teachers’ understanding may enable them to respond to their students based on a broader perspective of why they behave the way they do.

We demonstrated that teachers’ discourse had changed in various ways throughout the program. Their views of the brain shifted from thinking of it as a fixed organ to one that is in constant change. Most significantly, teachers realized that they have a significant role in bringing this change about (for better *and* for worse), depending on how they react/respond to their students. Furthermore, these changes are evoked both externally by the ways in which teachers react/respond to students, but they are also invoked internally as one engages mindfully with oneself (Davidson and Begley 2012). In some excerpts, these realizations were demonstrated when teachers were able to take the perspective of others, and this enabled them to respond more mindfully to day-to-day situations. We suggest that these realizations are crucial both for teachers’ day-to-day relationships with students, and for their overall self-concept as educators. As reflected in some accounts, teachers who are more convinced in their ability to engender positive change in themselves and in their students become more motivated (Meijer et al. 2009), and their motivation may inspire their students (Palmer 2010).

An additional aspect we highlight concerns the orientation of our study. As Hawley and Valli (1999) argued, there is limited research into the “core technology” of education, making it almost impossible for most programs to assure consistency in outcomes or coherence in process, which makes many pedagogies and education programs difficult to evaluate. This applies to research on teachers’ professional mindfulness learning as well. Indeed, research in this field has focused primarily on measures of mindfulness and well-being (Lomas et al. 2017; Meiklejohn et al. 2012) and

teachers' satisfaction from such programs (Jennings et al. 2011; Roeser et al. 2013) but less on aspects of *how* teachers learn mindfulness. As some argue, the *how* aspect of teacher learning is required for further developing the domain of MBIs for teachers (Meiklejohn et al. 2012; Roeser et al. 2012). In an attempt to respond to these calls as well as to elucidate our novel curricular pedagogical approach, our study sought to focus not only on the results of our program, but also on the processes that bring them about.

Limitations

Our study has a number of limitations. First, the findings reported here reflect the first cohort that has undergone this program and hence need to be tested with additional groups of teachers. Second, our methodology enabled us to explore changes at the group level and not at the individual level, which may as well inform future implementation. Third, the results obtained may have to do with the facilitator's expertise as both a neuroscientist and an MBSR trained teacher. Fourth, though findings show that through CBIs teachers underwent experiences of mindfulness, and there were indications of an enhanced mindful approach to teaching, we did not study these domains based on standardized mindfulness measurement tools (e.g., FFMQ). Fifth, we received responses that indicated teachers' interest in more CBIs; however, using a Likert scale questionnaire, which specifically asks teachers whether they would consider participating in an MBI before and after the program, could have improved our evaluation of the program's effectiveness in this respect. We avoided both standardized mindfulness questionnaires and the latter possibility because we wanted the program to raise curiosity toward mindfulness very subtly. Administering such questionnaires would have possibly compromised our efforts.

Our study shows that a program that is educationally (not therapeutically/clinically) framed, which integrates knowledge relevant for teachers with contemplative pedagogies, can serve as a fruitful and feasible orientation by which to expose teachers to mindfulness experiences and contribute to their day-to-day work and to their commitment to their role. We propose that this novel subtle mindfulness orientation might be developed not only based on contemplative neuroscience as in this case. The current proliferation of contemplative pedagogies across disciplines (Ergas 2017a; Owen-Smith 2018) suggests that this curricular-pedagogical orientation might be developed through other fields. Developing these subtler ways for introducing people to mindfulness may offer additional gateways to mindfulness, thus extending its appeal to broader populations.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The Interdisciplinary Center, Herzliya, (Israel) provided IRB approval for the study. All participants signed a statement of consent form and agreed to all research procedures.

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