ARTICLE

An Online Course in Contemplative Neuroscience Increases Dispositional Mindfulness and Reduces Meditation Barriers

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Teaching contemplative neuroscience is emerging as a way to increase the reach and relevance of our field to a wider undergraduate population while also encouraging the beneficial practice of contemplation. In-person classes on the topic have been shown to improve both academic learning and attitudes towards science and meditation. Here we show that a short-term, asynchronous online course in contemplative neuroscience had comparable benefits.

Students completed the Determinants of Meditation Practice Inventory (DMPI; Williams et al., 2011) and the Mindful Attention Awareness Scale (MAAS; Brown and Ryan, 2003) at the start and end of the course. Their scores showed reduced barriers to meditation and improved mindfulness after the course, changes predictive of a range of positive behavioral and well-being outcomes. Students also rated the course as highly effective in advancing neuroscience understanding and competency. A comparison group (from an online general psychology class) showed no increase in mindfulness and a significantly weaker reduction in meditation barriers.

This success of an online class in both academic and social-emotional learning is promising given the rapid growth of online instruction and the improved access it can provide to non-traditional students. The class format together with its health-relevant topic could thus be a valuable tool for reaching a more diverse student body while at the same time promoting practices linked to both personal and societal benefits.

Key words: contemplative pedagogy, meditation, mindfulness, contemplative neuroscience, health neuroscience, health studies

The 21st century blueprint for undergraduate "Neuroscience Studies" calls for interdisciplinary approaches that can serve a more diverse student body and expand neuroscience education "to a larger intellectual space" (Wiertelak and Ramirez, 2008; Wiertelak et al., 2018). Numerous recent initiatives have answered this call to make neuroscience more interdisciplinary as well as applicable and accessible for a wider range of students: Faculty describe fruitful approaches that promote "brain literacy", ease (neuro)science anxiety, and relate the field to inherent student interests such as health, meditation, yoga or literature (e.g., Salomon et al., 2015; Birkett and Shelton, 2011; McFarlane and Richeimer, 2015; Olson, 2018: Wolfe and Moran, 2017).

One effective practice involves stressing the natural connections between neuroscience and health to motivate a diverse mix of students to engage with neuroscience material (Been et al., 2016; Wolfe and Moran, 2017). With this focus on "health neuroscience" (Erickson et al., 2014), complex scientific concepts can be taught in an applied, health-related and hence practical way that is intrinsically interesting and motivating, even to non-majors.

A growing subfield in this area is contemplative neuroscience which examines changes in the nervous system with practices such as meditation and yoga. It is highly interdisciplinary (drawing on psychology, physiology, philosophy, and religion) as well as applied: Contemplative practice can support stress reduction, mental health and cognitive processes, as well as effect neural changes that appear to underlie these benefits, such as structural or functional changes in the brain, e.g., prefrontal cortex, limbic system, and thalamus (for example: Greeson, 2009; Goleman and Davidson, 2018; Streeter et al., 2010; Davidson et al., 2003; Hölzel et al., 2011; Tang et al., 2015; Cartwright et al., 2020).

Such findings are highly pertinent for college students who often face multiple stressors challenging their academic success and mental health, such as developmental stage, life transitions, and conflicting social, academic and financial pressures. Indeed, contemplation has become more popular on college campuses (Adams and Puig, 2008) and has been shown to help students' overall quality of life, stress, sleep, and mental well-being (e.g., Greeson et al., 2014; Gard et al., 2012; Eastman-Mueller et al., 2013). It is thus not surprising that classes incorporating contemplative experiences into the academic study of neuroscience material have positively engaged students and enhanced their learning experiences (Levit Binnun and Tarrasch, 2014; Olson, 2018: Wolfe and Moran, 2017).

Moreover, contemplative practice not only improves functions central to academic success and mental health, like self-regulation and attention. It also appears to promote pro-social dispositions, such as empathy and compassion (Davidson et al., 2012), skills needed to address "the big questions" of "meaning, purpose, and moral integrity" which also mark excellence in education (mission statement, Association of American Colleges and Universities; AAC&U, 2007). Such social-emotional learning goals also align with dimensions of the updated blueprints for neuroscience education (Wiertelak et al., 2018) which call for students' preparedness to serve "society's needs" and "ethical challenges". Finally, they are essential to the holistic, common-good missions of many institutions, such as ours: to “inspire students to lead, work and serve with the skill and empathy vital to creating a better world” (University of St. Thomas, Minnesota, 2022).

Given contemplation’s many benefits, both personal and potentially societal, approaches that encourage the practice among students should be welcomed. Many campuses already offer yoga and meditation classes focused appropriately on self-care, without formal instruction on the is science behind contemplative health benefits. There is evidence, however, that classes integrating such (neuro)scientific material could further increase student willingness to engage in contemplation.

As Ergas and colleagues (2018) note, studying principles of contemplative neuroscience can serve as a “gateway” to contemplation that, for some, might be more persuasive than meditation instruction itself: Misperceptions and resistance can hinder attempts to promote the practice

z	***Module***	***Readings***	***Videos***	***Assignments***	***Meditation***
1	Introduction, Neuroplasticity & Contemplation	Altered Traits, Ch. 3, 4 Syllabus, Term Paper Instructions	BBC documentary "The Power of Meditation" (55 min) https://youtu.be/7QYOiRsKAyg	Post Paper Topic	
2	Stress & Emotions, Compassion & Loving-Kindness	Altered Traits, Chapters 5, 6 Overview: Amygdala and Stress Response https://www.health.harvard.edu/staying-healthy/understanding-the-stress-response Article 1: Debordes et al. (2012)	Amygdala: Neuroanatomy and Function (2 min) https://www.youtube.com/watch?v=JVvMSwsOXPw	Post on Discussion Forum 1	Mindful breath, Metta/Loving-kindness (10-15 min each)
3	Attention, Brain's Default Mode Network	Altered Traits, Chapters 7, 8 Attentional Blink and Meditation (Lay summary): https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1865567/ Article 2: Brewer et al. (2011)	Attentional Blink (2 min) https://youtu.be/A1I7w6r2dm0 How Meditation Impacts the Brain (Selections, 8 min +) https://youtu.be/PCymeuQECOs	Quiz Modules 2, 3 Respond to Discussion Forum 1 Submit Annotated Reference Report for term paper	Body Scan Meditation (23 min)
4	Brain, Body, Genes; Psychotherapy	Altered Traits, Chapters 9, 10 Article 3: Lavretsky et al. (2013)	Meditation and Neuroplasticity (8 min) https://youtu.be/m8rRzTtP7Tc Meditation and Peripheral Biology (5 min) https://youtu.be/RGsU3jNvBRw Telomerase, stress and meditation (excerpts, 21 min) https://www.youtube.com/watch?v=a58RrLUs4YE https://youtu.be/2wseM6wWd74 Meditation as Psychotherapy (10 min) https://youtu.be/1A4w3W94ygA	Post on Discussion Forum 2: “Meditation as Therapy?”	Kirtan Kriya Meditation (13 min)
5	The Brains of Expert Yogis	Altered Traits, Chapters 11, 12 Lay Summary of Article 4: Gamma Wave Activity in Long Term Meditators. https://www.scientificamerican.com/article/meditation-on-demand/ Article 4: Lutz et al. (2004)	"A Joyful Mind" with Yongey Mingyur Rinpoche (9 min) https://youtu.be/l_3P-tOFp84 Studies on Expert Meditators (22 min) https://youtu.be/RGsU3jNvBRw	Respond to Discussion 2, "Meditation as Therapy?" Quiz on Modules 4, 5	Tibetan Meditation led by Mingyur Rinpoche (14 min) (on body, sensations, space, awareness)
6	Summing up & Looking ahead	Altered Traits: Chapters 13, 14, 1	The Science of Meditation (27 min) https://youtu.be/JAJ87Dwmx2E	Complete final term paper	Mindful Sitting Meditation (20 min)

Table 1. Course content and organization. “Altered Traits” refers to the book used for the course: “Altered traits: Science reveals how meditation changes your mind, brain, and body” (Goleman and Davidson, 2018).

directly through meditation programs (e.g., about the religious links, time commitment, personal fit) so that classes covering instead the science behind contemplative benefits might more easily reach some people. Accordingly, Olson (2018) reports that, next to enhanced learning and improved attitude towards science, students in a contemplative neuroscience class also reported lessened barriers to meditation, an important effect she ascribes to the evidence-based approach of the class.

In sum, classes in contemplative neuroscience not only address the need for "larger intellectual space" and interdisciplinary, applied study. They also enhance learning of neuroscience material through their practical, experiential nature. Finally, by potentially encouraging students to sustained contemplative practice, they might contribute to their well-being and academic success as well as to the larger, common good.

So far, effective classes described in the literature (e.g., Levit Binnun and Tarrasch, 2014; Olson, 2018; Wolfe and Moran, 2017) were all fully in-person and many lasted a full semester. However, an increasing number of institutions offer more flexible pathways with shorter, more intensive classes as well as more online offerings (Chmura, 2016; Roddy et al., 2017), a trend accelerated by the pandemic and likely to continue (McKenzie, 2021). It is hence imperative to establish that such teaching modalities retain the benefits of the more traditional methods, not only for academic but especially for social-emotional learning (Katzman and Stanton, 2020).

Olson (2018) showed that a short-term (one-month), in-person, intensive laboratory class for non-science majors (with 14 four-hour in-class meetings, a field trip, labs and meditation experiences) improved students' meditation barriers and science attitudes. Here, we build on these findings by reporting on an equally short, but less intense and fully online class in contemplative neuroscience that integrates scientific material with first-hand experience of contemplation. We show that the class was rated as highly effective in promoting neuroscience understanding and competency. Compared to a control course, it also strongly improved both dispositional mindfulness and perceived barriers to meditation, measures considered predictive of a range of positive behavioral and psychological outcomes. The success of such a class format is meaningful in part because of the rise of online instruction and the enhanced access and benefit it can provide non-traditional, underrepresented students (Pontes et al., 2010; Pontes and Pontes., 2012). The class format together with its applied topic could thus be a valuable means to boost diversity and equity in neuroscience education while also promoting health practices with wide-ranging benefits.

MATERIALS AND METHODS

All research was approved by the University of St. Thomas IRB and followed all ethical guidelines.

The course "Contemplative Neuroscience, NSCI 398" has been offered since 2019 as an intensive online class in either January term or Summer session at the University of St. Thomas (UST), St. Paul, MN. Taught by one of the authors (U.W.), it fulfils the neuroscience major's elective requirement and the psychology major's biological or cognitive requirement. As a prerequisite, students need to have completed one mid- or upper-level neuroscience or psychology class. The current article focuses on the four-credit course section taught over the four-week January term of 2021 (see Table 2 for demographics).

Required readings consist in the popular science book "Altered traits: Science reveals how meditation changes your mind, brain, and body" (Goleman and Davidson, 2018) together with primary literature articles and supporting materials, such as lay summaries or background readings related to the primary articles. The main book (Goleman and Davidson, 2018) uses the term 'meditation' for a wide range of contemplative practices, including mindfulness, loving kindness, yoga, etc. Accordingly, students in the class are exposed to a variety of approaches, as outlined below and in Table 1.

Instruction is asynchronous and online. In each week of the term, students complete one or two online modules (of a total of six) while also working on an independent term paper on a topic of their choice. Each module generally requires reading two chapters of the book and associated primary and supporting materials, viewing educational videos, practicing meditation with an online audio or video guide, and completing assignments, discussions, and/or quizzes. An overview of course content and organization is given in Table 1. To allow flexible scheduling of class work around other obligations, the absolute due date for the weekly modules is always Sunday, end of day. At the start of the course, before completing any materials, students took an online survey on their experience in any contemplative practice (type, length in years, weekly practice time in minutes) together with the 17-item Determinants of Meditation Practice Inventory (DMPI; Williams et al., 2011) and the Mindful Attention Awareness Scale (MAAS; Brown and Ryan, 2003). The DMPI measures perceived barriers to meditation by asking participants to rate their agreement with statements such as "My family would think it was unusual," "I don't have time," and "It is a waste of time to sit and do nothing" on a five-point scale, yielding summed scores between 17 and 85. Such barriers are important determinants of planned health behaviors so that the DMPI is thought to be predictive of future meditation intentions and practice.

The 15-item Mindful Attention Awareness Scale (MAAS) measures dispositional mindfulness defined as "open or receptive awareness of and attention to what is taking place in the present" (Brown and Ryan, 2003). Participants rate items such as "I do jobs or tasks automatically, without being aware of what I'm doing" on a six-point scale (1: almost

Class	Enrolled	% Female	% Seniors	% Juniors	% Sophom	% 1st-year
NSCI	21	76	81	19	0	0
PSYC '20	19	47	11	26	37	26
PSYC '21	17	47	23.5	23.5	23.5	29.4

Table 2: Student characteristics in each course.

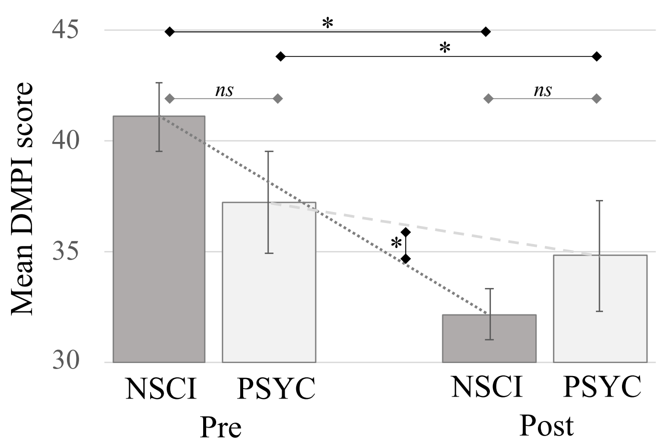

Figure 1. Mean DMPI scores for both classes, pre and post. Bars on columns denote standard errors. DMPI score decreased for both classes (see sloped, dashed lines) but significantly more strongly for the neuroscience class. Brackets with asterisk mark comparisons showing significant effects.

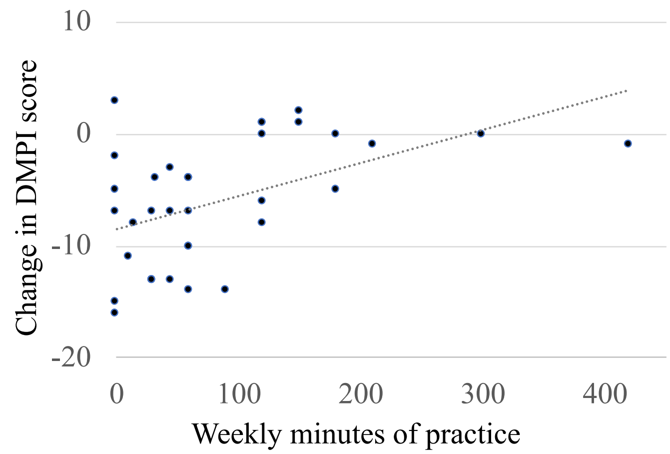

Figure 2. Pre-post change in DMPI with self-reported minutes of practice per week. Students with greater weekly practice time showed lower reductions in their DMPI score (i.e., their change scores are less negative).

always; 6: almost never). Scores predict a range of self-regulation and well-being measures, with higher scores correlated to, e.g., lower mood disturbance, unpleasant affect and stress as well as higher autonomy in daily life.

Students took both scales again at the end of the term. One additional open-ended question also asked them to list the three greatest benefits (academic and/or personal) gained from this course.

Comparison Group

Students in a general psychology class (PSYC 111) served as a comparison. The course is taught by the same professor during the slightly longer (6.5 weeks) summer session in the same fully online and asynchronous format. In this class, meditation is not a focus, but briefly covered in three of the 15 textbook chapters (Gazzaniga, 2018) as having benefits for relaxation and (mental) health: states of consciousness (Ch. 4), health psychology (Ch. 11), and treatment of psychological disorders (Ch. 15). Students in the Summer 2020 section took the DMPI and the survey of previous contemplative experience, whereas students in the Summer 2021 section took the MAAS. As shown in Table 2, the demographics of the two sections were similar indicating that they can be considered equivalent comparison groups.

Grading and assignments

Grading in NSCI 398 is based on three components: Writing assignments and discussion posts (45%), online, open-notes quizzes (25%), and a term paper with related scaffolding assignments (30%).

Course Objectives

The student course rating system at UST asks instructors to select two to four class objectives (from a standard list of 12) and to explain to students what these mean in the context of the class. For this course, the three objectives are:

1. Gaining a basic understanding of the subject (e.g., factual knowledge, methods, principles, generalizations, theories) of contemplative neuroscience
2. Learning to analyze and critically evaluate ideas, arguments, and points of view
3. Learning to apply course materials and skills to benefit others or serve the public good

Specific learning outcomes were formulated as follows:

1. Discuss the prominent findings in contemplative neuroscience
2. Apply neuroscientific research methods to explore the effects of contemplation.
3. Critically evaluate the evidence that contemplative practices can benefit mental and physical health.
4. Discuss how findings from contemplative neuroscience might be applied to benefit yourself and others.
5. Analyze issues in the field through literature and writing

Course Ratings

In the anonymous end-of-semester course ratings, students are asked to assess their progress on the three main course objectives on a five-point scale (1: No apparent progress; 5: Exceptional progress). They are also asked to indicate their agreement with the statement: “Overall, I rate this instructor/course as excellent” on a five-point scale (1: Definitely False; 5: Definitely True).

RESULTS

Results show that the contemplative neuroscience class led to strong decreases in perceived barriers to meditation and increases in dispositional mindfulness. These effects were significantly different from those of the psychology class:

DMPI

The NSCI class showed a stronger reduction in perceived barriers to meditation than the PSYC class. Of the 21 (18) students in the NSCI (PSYC) class, 20 (16) completed the DMPI. 10 or 56% (9 or 56%) were female. A 2x2 mixed factorial ANOVA (*Class* (NSCI, PSYC) as between-subject factor, *Time* (pre, post) as within-subject factor, Box's M=7.78, p=0.064 confirming equality of covariance matrices) showed a main effect for *Time* (F(1,34)=56.8, p<0.001) and an interaction between *Time* and *Class* (F(1,34)=19.1, p<0.001), such that the NSCI class had a stronger reduction in scores, pre to post. Partial eta squared values were 0.63 (*Time*) and 0.36 (*Time x Class*) indicating large effect sizes for both the main effect and interaction. The main effect of *Class* was not significant (F(1,34)=0.061, p=0.81). A post-hoc analysis showed that both classes had significant reductions in the DMPI scores, pre to post (NSCI: -8.95, p<0.01, PSYC: -2.38 p<0.05 with Bonferroni adjustments), but that the two classes compared at the same time (pre or post) were not different in their DMPI scores (pre: p=0.15, post: p=0.31). This pattern can be seen in Figure 1, with descriptive statistics shown in Table 3: Both classes show lower DMPI scores in the post measure, but the reduction in scores is much stronger for the NSCI class as also evidenced by the large effect size for the interaction term (see above, partial eta squared value: 0.36).

Unlike in Olson's (2018) sample, students with previous meditation experience did not differ in the pre-post change in DMPI from those without experience (independent t-test on pre-post DMPI difference: T (34)=0.47, p= 0.64). However, only six of the 36 participants reported no previous experience (two in PSYC, four in NSCI) possibly explaining this null result. We thus also correlated amount of experience to changes in DMPI. Neither years of practice nor total time of previous meditation (calculated as: years of practice x 52 x weekly time of current practice) were significantly correlated with DMPI change (r(34)=0.28 (total time) r(34)=0.05 (years), p>0.05). As shown in Figure 2, however, current minutes of weekly practice were significantly correlated with the change in DMPI, such that students with more minutes of current weekly practice had less of a reduction (r(34)=0.48, p<0.005).

MAAS

The NSCI class, but not the PSYC class, showed an increase in dispositional mindfulness. Seventeen (14) students in the NSCI (PSYC111) completed the MAAS. A 2x2 mixed factorial ANOVA (*Class* (NSCI, PSYC) as between-subject factor, *Time* (pre, post) as within-subject factor, Box's M=3.40, p=0.064 confirming equality of covariance matrices) showed no main effect for *Time* (F(1,29)=1.82, p=1.88) or *Class* (F(1,29)=2.45, p=1.29) but a strong interaction between *Time* and *Class* (F(1,29)=13.79, p<0.002; partial eta squared value: 0.32). Post-hoc analysis showed that only the NSCI class had a significant increase in the MAAS score, pre to post, while the PSYC class showed a decrease that did not reach significance (NSCI: 0.57, p<0.002, PSYC: -0.26 p=0.121 with Bonferroni adjustments). The two classes compared at the time of the pre-test were not different in their MAAS scores, but were for the post-test (pre: p=0.79, post: p<0.005, with Bonferroni adjustments). This pattern can be seen in Figure 3 and Table 3: Only the NSCI class shows an increase in MAAS scores in the post measure, as also evidenced by the large effect size for the interaction term (see above, partial eta squared value: 0.32).

The pre-post changes in MAAS were not correlated to previous or current meditation experience (for all tests, |r|(15)<0.47, p>0.05. Here, data on previous experience were only available for the NSCI class).

Qualitative Data

The answers to the open-ended question (as to the three greatest benefits, academic and/or personal, gained from the course) further illustrated that students developed a more positive attitude towards contemplation with reduced perceived barriers to a practice. They commented that the scientific evidence increased their motivation to meditate (and even encourage others to), that the variety of methods gave them more options to practice more readily and that they experienced benefits first-hand. The following are representative comments:

> *From this course, although I did practice meditation in the past, I have been more open to trying different types other than body-scan and mindfulness. It has really opened my eyes to more active/engaging forms of meditation such as loving-kindness or Kirtan Kriya. I am really glad I discovered these forms through this course and prefer these practices over mindfulness and breathing meditation forms in which I was practicing strongly prior.*

> *The biggest benefit was learning about the different forms of contemplative neuroscience. […] the different forms have given me a variety of choices to use for practice.*

> *I've learned so much about how meditation can be helpful and have seen the evidence to prove it, so I won't be as hesitant to do a guided meditation in the future.*

> *I have always done meditation simply because of the subjective feeling and increased awareness, but knowing that there are possible, measurable, physical changes occurring, I have become more intrigued.*

> *I feel like I have a new way of dealing with stress.*

> *I think that my mental and physical health has improved.*

> *Improved attention and less anxiety as a result of meditating more.*

> *I now feel that I have time to incorporate meditation into my daily life!*

> *I think that meditating could be very helpful to me in the future, especially since I struggle with anxiety and focus, so I plan on continuing to practice in the future. I believe this could help improve my mental health and possibly grades.*

Class	N	Survey	Mean	Std. Dev.
		DMPI:		
NSCI	20	Pre	41.10	6.87
		Post	32.15	5.22
PSYC	16	Pre	37.19	9.25
		Post	34.81	10.03
		MAAS:		
NSCI	17	Pre	3.45	0.79
		Post	4.02	0.58
PSYC	14	Pre	3.52	0.60
		Post	3.26	0.75

Table 3. Descriptive statistics for DMP and MAAS data.

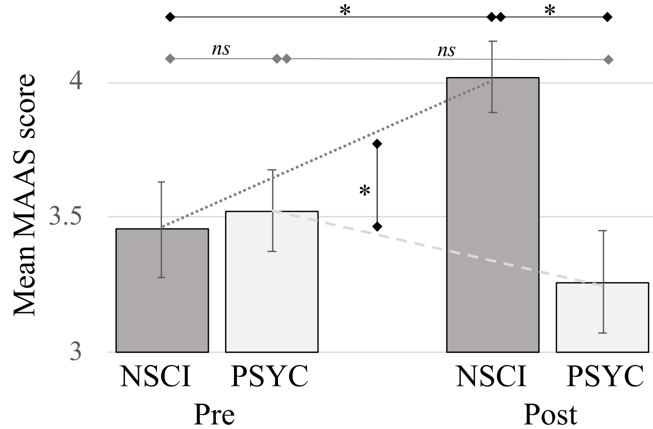

Figure 3. Mean MAAS scores for both classes, pre and post. Bars denote standard errors. MAAS score increased only for the NSCI class, while decreasing non-significantly for the PSYC class (see sloped, dashed lines). Brackets with asterisk mark comparisons showing significant effects.

I learned that meditation not only helps with overall well-being but has actual effects on the brain […] I can now try and help family members who struggle with certain disorders overcome by using various forms of mediation (or at least try).

The psychological and physical changes due to meditation are real! They aren't just claims, but there is scientific evidence to back up the fact that meditation really helps people whether they are healthy or battling an illness.

Greater passion for neuroscience because of that immediate practicality that's measurable.

Student Course Ratings

In their anonymous online ratings, students indicated that they had made strong progress on the three chosen course objectives and that they rated the course and instruction overall as highly positive. They also indicated that they perceived themselves as having gained the “specific skills, competencies, and points of view needed by professionals in the field most closely related to this course”, another objective that indicates their perception that the class advanced their neuroscience knowledge. Figure 4 shows overall mean ratings for these five items (range: from 4.5 to 4.7, with 5 being the maximum and 3 a neutral rating).

DISCUSSION

Teaching contemplative neuroscience has recently emerged as a fruitful approach to grow the reach and relevance of our field to a diverse student body. The interdisciplinary, applied, experiential and health-relevant nature of the topic encourages learning of scientific concepts and improves attitudes towards science (Levit Binnun and Tarrasch, 2014, Olson, 2018; Wolfe and Moran, 2017). Its evidence-based focus can also foster students' readiness to practice contemplation, even where direct meditation instruction might fail (Olson, 2018; Ergas et al., 2018). This is an important effect, given the potential benefits of contemplation, both personal and societal.

These benefits for academic and social-emotional learning have so far only been shown for in-person classes on the topic. With the accelerated rise of online, distance instruction, however, it is crucial to establish that they persist in this modality as well. Here we show that they do. Our fully online, short-term class in contemplative neuroscience enhanced academic and social-emotional learning: It reduced perceived barriers to meditation, indicating greater likelihood to engage in the practice. It further improved dispositional mindfulness, a predictor of a range of psychological well-being and self-regulation measures. Finally, it was also rated as effective in promoting neuroscience understanding and competencies.

We found strong effect sizes for the improvements of meditation barriers and mindfulness, even when compared to a control group. Our data showed no difference in the pretest scores and thus seem to rule out self-selection into the neuroscience class as an explanation for our results. Moreover, while we do not have the data for a statistical comparison to previous research results, our average DMPI reduction (8.95 points for the NSCI class) was as large as the one reported for an in-person class with a laboratory component (Olson, 2018). Some of our other results also converge with Olson's (2018): In her research, students with less previous contemplative experience showed the greatest reduction in their meditation barriers. While unlike her, we did not find that the size of reduction in DMPI depended on *previous* contemplative practice (perhaps because of the low number of students without previous practice in our sample) we report a correlation to *current* weekly practice time, with greater current practice time linked to smaller decreases in barriers. Olson (2018) showed that improvements in science attitude correlated with reduction in perceived barriers. Here, student comments similarly suggest that lowered barriers were prompted by increases in scientific understanding, while conversely their respect for neuroscience grew due to the applied nature of the course. This lends further support to the idea of contemplative neuroscience as a “gateway to mindfulness” (Ergas et al., 2018). Finally, as in Olson (2018), several students commented on the range of practice options introduced in the class and credited it with increasing their readiness for regular practice.

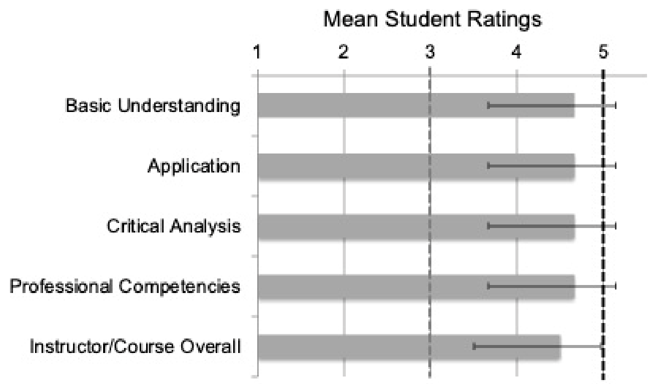

Figure 4. Mean ratings for five evaluation items (see text for details). Error bars denote standard deviations. Black dashed line marks most positive rating possible (5), grey dashed line marks neutral rating (3).

This success of a fully online, short-term class is encouraging for several reasons: Online learning is likely here to stay, even post-pandemic (McKenzie, 2021), so it is crucial to show it can advance students not just academically but especially in their social-emotional and personal development (Katzman and Stanton, 2020). Our success in this domain is shown in the increases in dispositional mindfulness, previously linked to a range of positive behavioral and well-being outcomes, and lowered barriers to meditation indicative of greater future likelihood to engage in this beneficial practice.

The flexibility of online learning can also open avenues for non-traditional, underrepresented students into the field, thereby furthering the goal of greater diversity and equity in neuroscience education. For example, not only do non traditional undergraduates and those with physical disabilities show greater preference for distance learning (Pontes et al., 2010), but non-traditional students also show reduced enrollment gaps as a result of access to such learning (Pontes and Pontes, 2012).

Reliance on the many online meditation guides in this course also obviates the need for specialist instructors in meditation, a potential obstacle for some neuroscience faculty. It moreover immediately initiates students into the type of guided practice they can continue without any interruption after the end of the class.

The absence of any space requirements and the inexpensive readings (a popular science book and free online articles) furthermore make the course an accessible template for a range of institutions. Classes like ours might complement yoga and meditation courses already offered on many campuses that provide stress relief and self-care, without examining the science for these benefits.

Moreover, the class material could be adapted into a shorter module on contemplative neuroscience for use in a range of health-related courses. At UST and similar schools, existing classes with a suitable fit include those on clinical and counseling psychology, personal or public health/wellness, stress management, and drugs/alcohol. As we wrote previously (Wolfe and Moran, 2017), knowledge of the science behind contemplation's benefits, while of value to all, might be especially important for students in those (mental) health fields without strong neuroscience requirements as they will have to critically assess related health claims in their future profession. Our current course material could be condensed into a general-audience module by dropping the term paper requirement and primary readings and adjusting the quizzes accordingly. We are currently collaborating with a group of researchers in complementary health care on developing such a module for a holistic counseling program for health workers, and we are starting a similar effort for UST's future nursing program. In sum, we hope that the effective approach outlined here can help integrate contemplative neuroscience into the wider curriculum and reach more diverse students through a subject directly meaningful to their lives and professions.

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