THE EMORY-TIBET SCIENCE INITIATIVE, A NOVEL JOURNEY IN CROSS-CULTURAL SCIENCE EDUCATION

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THE EMORY-TIBET SCIENCE INITIATIVE, A NOVEL JOURNEY IN CROSS-CULTURAL SCIENCE EDUCATION

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EDITORIAL
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Editorial: The Emory-Tibet Science Initiative: A Historic Collaboration Between Modern Science and Tibetan Buddhism—Insights From a Spiritual Leader

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Editorial on the Research Topic

The Emory-Tibet Science Initiative: A Historic Collaboration Between Modern Science and Tibetan Buddhism-Insights From a Spiritual Leader

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Today, any Tibetan Buddhist monastic who is considering earning the highest academic degree in his or her institution must complete a 6-year curriculum in physics, neuroscience, and biology. Why? Why would an ancient religion that originated and evolved in the Global South invite modern scientists from the Global North into its monastic universities to teach and integrate science into the curriculum: *expand*, and contextualize the curriculum rather than narrow it as has occurred with most advanced degrees in the US?

The Emory-Tibet Science Initiative (ETSI), our project teaching modern science to Buddhist monastics, emerges from the Dalai Lama's years-long engagement with scientists to discuss how to effectively integrate scientific knowledge and the knowledge of Indo-Tibetan traditions to best serve humanity. The spiritual leader of Tibetan Buddhism represents the centuries-old Nalanda tradition, a worldview grounded in the idea that in order to understand your own worldview, you must understand everyone else's. Thus, the Dalai Lama's invitation to scientists in 2008 to catalyze the first major renovation of his monastics' curriculum in 600 years was a major step toward integrating scientific and traditional knowledges.

The Dalai Lama always had a curiosity and reverence for science. As a child, he used a telescope that belonged to his predecessor to peer into the night sky in the high altitude of Tibet, which offers one of the most spectacular views of the stars. He has a lifelong hobby of dismantling and reassembling mechanical objects, mastering such processes well enough to become a repairer of watches in his childhood Tibet. He came, in time, to recognize the technology he found so interesting was the fruit, or expression, of a scientific approach to investigating the world.

Over the years, the Dalai Lama became fascinated with this approach and began to notice similarities in the spirit of inquiry between science and Buddhist thought. He saw science first and foremost as a mode of inquiry that gives detailed knowledge of the world and the underlying laws of nature, which we infer from empirical data. Science proceeds by means of a very specific method that involves measurement, quantification, and verification through repeated experiments. Buddhism has a similar investigative spirit. Although Buddhism has come to evolve as a religion with a characteristic body of scriptures and rituals, Buddhist scriptural authority cannot outweigh an understanding based on reason and experience. In fact, the Buddha himself famously undermines the scriptural authority of his own words when he asks his followers not to accept the validity of his teachings simply on the basis of reverence for him, but to test the truth of what he said through reasoned examination and experience. So, one fundamental attitude shared by Buddhism and science is a commitment to the continual investigation of reality by empirical means and a willingness to discard accepted or long-held positions if investigations suggest that the truth is different.

The Dalai Lama resonates with many scientific discoveries and ideas. He is especially struck by Darwin's theory of evolution, by the tenets of quantum physics, and by the contributions of science to our quality of life and life expectancy. He points out, though, that without an ethical framework, the discoveries of science can be mis-used and cause great harm. An ethical imperative is especially relevant today, given advancements in synthetic biology that soon may allow scientists to edit the human genome and alter the evolutionary future of humanity. Like any instrument, science can be put to good use or bad. It is the state of mind of the person wielding the instrument that determines to what end it will be put.

In Buddhism, the highest spiritual ideal is compassion, and the Dalai Lama strongly encourages science during the 21st century be guided by this north star of compassion, and a commitment to enhance the welfare and well-being of all sentient beings. He believes that science would benefit from a "secular ethics," that is, an ethics that does not rely on any particular belief system, but one that can be embraced and practiced by both those who follow a particular faith tradition and those who do not. The goal of such ethics is to ensure that science never becomes divorced from the basic human feelings of empathy, connection, and compassion with our fellow beings.

Although science and Buddhism share a commitment to an empirical mindset, they frequently differ in their methods. Science typically uses instruments, quantitative methods and third-person perspectives to examine external phenomena. Buddhism, by contrast, understands the importance of first-person observation and the development of refined attention to directly observe both inner and outer states—mind and body, and their interactions with the external world. The challenges of today's world suggest we are at a point in history where these two traditions can, and should, start working together, communicating across the boundaries of religion, science, values, and culture.

The Dalai Lama invited scientists into monastic universities to help facilitate this collaborative relationship. The ultimate goal of ETSI is to build bridges between two complementary systems of knowledge by educating Tibetan monastics in science, so they can become potential collaborators in the science of mind and body. ETSI is designed to give Tibetan monastics new tools for understanding the world, while also providing them with fresh perspectives on how to employ and adapt time-tested, Buddhist, contemplative methodologies for the relief of suffering in the contemporary world.

This is a monumental exercise at the frontiers of 21st century communication. But this unprecedented opportunity for transformation also presents challenges and demands critical consideration. While the Dalai Lama requests that the scientists "just teach the science" to the monks and nuns, inevitably students and teachers ponder, question, and debate the overlaps, similarities, and disconnects between science and Buddhism—both because they are striking, and because good teachers always draw on their students' pre-existing knowledge and experience. A great challenge of ETSI, and of any meaningful cross-cultural interaction, is effective communication. Effective communication of the deepest kind requires a recognition and integration of basic human values—kindness, compassion, forgiveness, and generosity. Tibetan Buddhism holds these values as necessary for the flourishing of human society. This special issue of *Frontiers in Communication* is rich with data from participants in ETSI—scientists, monastics, and lay Tibetan translators—that illustrate how these basic human values, so central to Tibetan Buddhism, transform their thinking about science and religion and about communication, both *within* the project and, perhaps even more powerfully, back in the participants' "home" institutions—the centers of monastic studies and the "western" science labs and classrooms.

The Buddha is credited with saying, "when the student is ready, the teacher will appear." Through ETSI, the student has become the teacher, and vice versa. And what has emerged is a rich and historic conversation between academic science and Indo-Tibetan traditions that we hope can help us better address the problems of humanity and make the world a more compassionate place.

AUTHOR CONTRIBUTIONS

RN wrote a first draft, AE shaped it into a second draft, and all the other authors contributed comments and rewrites.

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EDITORIAL
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Editorial: The Emory-Tibet Science Initiative, a Novel Journey in Cross-Cultural Science Education

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Editorial on Research Topic

The Emory-Tibet Science Initiative, a Novel Journey in Cross-Cultural Science Education

Perhaps the greatest global challenge of the 21st century is how to effectively communicate—across cultures, ideologies, disciplines, and experiences. The current pandemic is a dramatic illustration; we are one world, bound together by biology, economics, and environment, yet riven by suspicion of science, by religious and racial conflict, cultural and political divisions. And we see the cost in lives, money, energy, and social capital. The need for models of "positive globalization"—strategies for and examples of meaningful and symbiotic integration and communication—has never been greater.

The Emory-Tibet Science Initiative is just such a model (Emory Tibet Science Initiative, 2020). ETSI is an historic collaboration—between American and monastic universities, science and religion, and different worldviews. The accompanying introductory editorial outlines the Dalai Lama's views on science and Buddhism and his reasons for initiating and inspiring the project (Nusslock et al.). ETSI has built a comprehensive modern science curriculum integrated into the traditional monastic training of displaced Tibetan Buddhist monks and nuns in India, the first significant change to their curriculum in six centuries. The project, now in its second decade and involving hundreds of scientists and thousands of monastics, provides a rich and rare opportunity for exploring challenging communication issues: (1) questions of cultural and literal translation; (2) best practices in teaching science and engaging research across cultures and within a religious community; and (3) the impacts of bi-directional education, prompting new understandings of culturally-relevant pedagogy at both American and monastic universities.

This special issue addresses the broader problem of how to most effectively teach and communicate—across vastly different cultures and ways of thinking—in pursuit of learning. Few "experiments" in recent times provide a better laboratory on a larger scale for addressing this question than ETSI. We feature many scholars from both the Buddhist and scientific communities who have built and maintained the science curriculum, laboratories, and physical, social, and intellectual infrastructures in the monasteries and nunneries over the last many years. This includes three different stakeholder groups: monastic instructional leaders, Tibetan interpreters and translators, and scientists and philosophers from the Global North.

For ETSI, Tibetans translate the teachings in real time and translate dozens of texts and teaching materials. Physicists, biologists, neuroscientists, and philosophers of science develop curricula, teach the monastics, and engage them in research projects in India and the US. Monastic instructional leaders mastered science and English at Emory, then returned to

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their home institutions to teach their peers. These three stakeholder groups have navigated different ways of knowing as well as communicating to collectively identify how to best support monastics' science learning.

This collection features an introductory overview from the perspective of the Dalai Lama, the catalyst and inspiration for this project, and reflective essays and research articles addressing key components and ongoing lessons of ETSI from representatives of all its constituents. Science educators describe and explore novel pedagogies, approaches, and techniques they develop to teach and engage monastics on the ground. Others explore how their monastic teaching deeply impacts how and what they teach back at their home institutions, changing the way they think about their own science and even how they develop their research programs. Two monastic science students themselves write essays that combine scientific and Buddhist insight. The ETSI translation team of lay and monastic educators and scientists discusses the rich tradition of translation in Tibetan Buddhism and their creation of a new Tibetan science dictionary (cite).

Articles co-written by American or European scientists with monastics (both monks and nuns) or lay Tibetan scientists and educators illustrate the symbiotic maturation of the project. A team of American and Tibetan scientists and monastics analyze the effects of learning science on the monastics' views of science and their lives, and how the monastics mediate across worldviews. A neuroscientist and one of his former monastic students dive deep into consciousness, one of the areas Tibetan Buddhism most readily engages science. Science educators write with a monk and a nun about the power of metaphor and narrative in teaching science across cultures.

American and Tibetan researchers characterize monastic mental states through a nuanced translation of a self-administered "Western" mental health screening tool; effective cross-cultural communication requires that we understand where mental states potentially align and diverge. The use of drawing to learn concepts in biology reveals the mental models drawn from monastic cultural references.

In sum, the fruits of the Emory-Tibet Science Initiative and the collection assembled here reveal how two groups separated by seemingly disparate cultures, beliefs, and distance find common ground, how deep cross-cultural communication both enhances the ongoing work and understanding within each culture *and*, at the same time, creates a novel space for exploration and discovery.

AUTHOR CONTRIBUTIONS

AE wrote the initial draft with JZ making significant contributions. MB, GH, RN, and LN providing insightful additions, edits, and suggestions for revisions. All authors contributed to the article and approved the submitted version.

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BRIEF RESEARCH REPORT
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Drawing-to-Learn: Active and Culturally Relevant Pedagogy for Biology

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Students enter biology classrooms with ideas about the natural world already formed. Teachers can help students construct new knowledge by using active, culturally relevant pedagogy and by making space in their lesson for students to reveal, challenge, and/or reconcile their preconceptions with new knowledge. Drawing meets all of these needs. Drawing-to-learn (DTL) allows students to be metacognitive and creative as they generate concrete representations of their abstract conceptions. In this case study of biology classes for Tibetan Buddhist monastic students through the Emory-Tibet Science Initiative, we find that DTL engages students in active learning, allows multi-modal visualization and discourse about mental models, and beyond this, solicits cultural references from both students and teachers.

Keywords: drawing-to-learn, monastics, Tibet, biology, teacher-student discourse

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INTRODUCTION

For years, researchers have implored biology instructors to use active learning pedagogy to help increase student understanding of biology concepts and to strengthen class performance (Freeman et al., 2014; Haak et al., 2011; Theobold et al., 2020). Strategies such as writing-to-learn (WTL), small group work, and problem solving in project-based assignments encourage students to explore content more deeply, to recall prior knowledge, and to articulate their developing conceptions (Andrews et al., 2011). The efficacy of active learning has been well demonstrated (Deslaurier et al., 2019; Freeman et al., 2014; NRC, 2003), except when instructors are unaware of how to design meaningful activities (Andrews et al., 2011; Bloodhart et al., 2020).

One of the intentions of active learning pedagogy in biology classes is for both students and teachers to uncover student's preconceptions about the natural world. These preconceptions may reflect student's cultural or personal funds of knowledge, the socioculturally-informed knowledge that has been acquired in one's daily life (Moje et al., 2004; Moll, 2019). Not all active learning strategies are equally successful in 1) prompting discourse that allows students to reconcile potentially conflicting conceptions about the natural world and 2) revealing students' ways of knowing (Balgopal et al., 2012; Balgopal et al., 2021). If teachers wish to introduce students to new ways of knowing, both must have a chance to identify prior knowledge and any worldviews affecting student explanations of natural phenomena, as these are potential reasons for student's confusion or alternative conceptions. Moreover, teachers need pedagogical practices that make abstract conceptions salient (Balgopal et al., 2017; DeNoyelles and Reyes-Foster, 2015).

Science instructors have long depended upon images in their textbooks, lectures, and assessments, yet research on drawing-to-learn in science classes has been sparse, especially when compared to writing-to-learn (Bell, 2014; Prain and Tytler, 2012; Tippett, 2016; Yore et al., 2003). In this paper, we adhere to Quillin and Thomas' (2015) definition of drawing: "a learner-generated external visual representation depicting any type of content, whether structure, relationship, or process, created in static two dimensions in any medium (p. 2)." Note that this definition is broad in regard to content but narrow in its insistence upon student creation-not only interpretation-of visuals. Thus, an instructor's frequent use of diagrams, figures, maps, or charts is not, in and of itself, a use of DTL pedagogy (Tippett, 2016). No matter how often students are asked to interpret symbols and images in their science classes, for strong visual literacy, they need to create their own representations of science concepts and phenomena (Lowe, 2000; Schonborn and Anderson, 2006; Gilbert and Treagust, 2009; Ainsworth, 2011). In other words, students must actively choose content and composition, and must, themselves, generate a material illustration. In doing so, students have the freedom to draw upon cultural references and symbols.

DTL can take many forms in the classroom. Drawing can fill large portions of laboratory notebooks, where students keep records of specimens, experiments, and observations (Germann and Aram, 1996). Shared drawings can serve as essential prompts and tools for class or small group discussions (Atkins Elliot et al., 2016; Goldschmidt, 2007; Lowe, 2000; Park et al., 2020). Drawing can be tied to journaling, an exercise that can also prompt students to use expressive writing to explore a topic (Cormell and Ivey, 2012; O'Keefe and Paige, 2020). In their comprehensive DTL review, Quillin and Thomas (2015) provided a valuable list of 13 reasons drawing may be integrated into science curricula, including drawing to: interpret visual information, enhance motivation, reveal misconceptions, support learning, enhance observation, enhance model-based reasoning, connect concepts and ideas, enhance metacognition, convey quantitative information, teach skills, reinforce the role of visual design in science communication, reveal student's mental models, and communicate to others. We argue that the last two in this list make DTL uniquely well-suited to call attention to, or make salient, student's worldviews and thus to help both students and teachers reconcile new biology concepts with diverse preconceptions. We share here, as a case study, the drawing activities we integrated throughout our biology instruction of Tibetan Buddhist monastics in the Emory-Tibet Science Initiative (ETSI).

METHODS

We have used a case study methodology (Yin, 2009) to explore the role that DTL interventions can have in promoting communication between instructor and students in biology courses for adult monastics. Such case study research is especially useful for phenomena in temporally- and spatially bounded contexts (Stake, 2005) and provides a naturalistic approach to learning about the process and product of the case(s) being studied (Stake, 1995). Using an intrinsic case study design, we sought to characterize the unique role that DTL played in cross-cultural biology classes for Tibetan Buddhist monks living in India (Crowe et al., 2011).

Context

Emory University in the United States (U.S.) and monastic universities in Tibetan settlements in India collaboratively created the ETSI program to offer academic natural science instruction to Buddhist monastics (monks and nuns). Science instructors from a wide range of universities were invited over a decade to participate in teaching biology, neuroscience, physics, and philosophy of science courses. Currently, monastic science leaders are transitioning to be lead instructors at their universities. Monastic students ranged in age from early-30's to mid-40's, and around 100 students were enrolled in each course. Because monks and nuns resided at separate institutions, classes were not often co-ed. Both authors have participated in the program (AFE for 7 years and MMB for 5 years), teaching biology courses to monastics or assisting monastic science teachers in curriculum development.

Courses and Interventions

Outside of ETSI, both authors have integrated WTL and DTL into our undergraduate biology courses in the U.S. In our ETSI biology courses, we used a variety of DTL activities, including both in class and homework drawings, conducted collaboratively or alone, as stand-alone assignments or in conjunction with other activities, in notebooks, on index cards, on large pieces of butcher paper, or on other media, and in English, Tibetan, or whatever symbols were meaningful to the student. We most often and regularly asked students to keep class journals, notebooks in which they recorded and reflected on concepts. These were then voluntarily shared in class with peers and the instructors. Our WTL/DTL assignments were both observational (recording what they saw during class activities) and conceptual (recording abstract ideas on paper), but for this case study we focused on the conceptual assignments. Conceptual assignments required students to recall their prior knowledge (academic, personal, theological/cultural, linguistic, etc.), as they negotiated new biological knowledge introduced in their ETSI courses.

Data Collection and Analysis

The primary source of data used in this study included recorded images (photographs) of student-created drawings. Other data referenced in the analysis included: audio-recordings and transcripts of translations of student explanations of their drawings, curricular materials, reflections of our teaching experiences during the respective courses, and recorded images of artwork and drawings that we observed at the monastic universities and Tibetan settlement during our teaching experiences. After obtaining Institutional Review Board approval (053-16H) from Colorado State University, we methodically recorded images of the WTL/DTL assignments and student work. Students were invited to have their notebooks, journals, and drawings photographed. ~25% of each ~100 student class volunteered. If they or a translator explained what the images were (i.e., cultural significance), these explanations were audio-recorded or documented in English. All images and recordings were stored in a shared cloud-based folder. Using thematic analysis, we iteratively reviewed all of our respective images independently (Braun

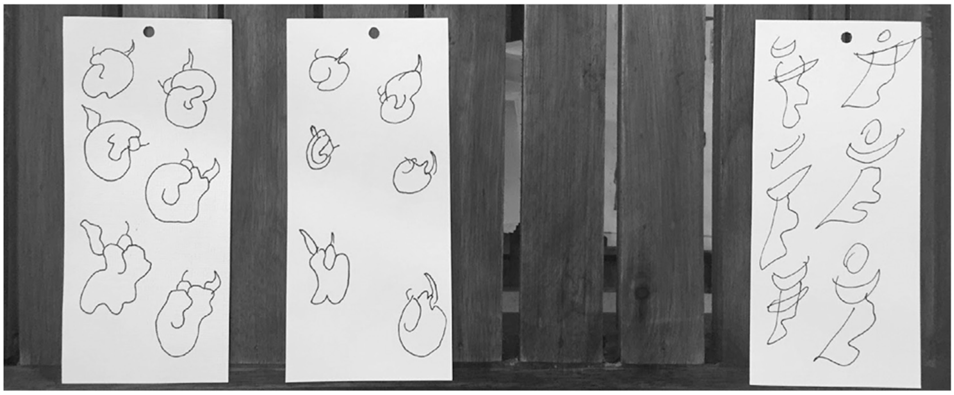

FIGURE 1 | A drawing activity used to illustrate the concept of accumulated mutations. Students saw images on a card **(far left)** and recreated them. Over 100 students participated, but after only 30 students had recreated the images **(far right)**, the images were already drastically different.

and Clarke, 2006) through a deductive analytic process using Quillin and Thomas (2015)'s typology and identified initial themes: enhancing meta-cognition, revealing misconceptions, and visualizing quantitative data (**Supplementary Appendix**). We initially grouped drawings based on the type of drawing: observational, conceptual, realistic, or abstract. We defined observational drawings as recordings of what monastics saw, while conceptual drawings were of ideas generated in or out of class. Realistic drawings were recognizable to both the viewer and the drawer, while abstract illustrations were meaningful to primarily the drawer, unless the viewer was familiar with symbols, colors, and orientations of the drawings. We also identified an additional code (fostering cross-cultural discourse) that was not emphasized in Quillin and Thomas (2015) and selected examples to exemplify our findings. After returning to the DTL and visual literacy literature, we finalized our themes and ensured full inter-rater agreement.

RESULTS

We found that when teachers and students bring different cultural perspectives to class, the concrete drawings generated through DTL activities, such as those we used in our ETSI classes, can enrich class discussions in two prominent ways. First, as with most active learning strategies, DTL is multi-modal, engaging students in not only the creation of visual drawings but in associated verbal discussion and written text. Second, DTL focuses both student and teacher attention on reconciling academic knowledge with cultural funds of knowledge.

Drawing to Promote Active Learning

As biology instructors in the ETSI program, we described processes –– both biological processes (e.g., cell division, speciation), and research processes (how investigations are designed and conducted). Teaching processes can be challenging because of temporal or spatial constraints and/or because they involve multiple steps. During a lesson that one of our co-instructors (Nicole Gerardo) taught about how the accumulation of microevolutionary changes (e.g., mutations) results in large macroevolutionary outcomes (e.g., speciation), ETSI monastic students participated in a drawing exercise asking each of them to recreate a squiggle drawing. Each student saw only the squiggle drawing created by the last person (**Figure 1**). After passing through 100 students in the class, the squiggle drawings accumulated so many small changes that they no longer resembled the original drawings. These drawings on cards were hung up around the room, where they demonstrated a process and reinforced an abstract concept about variation that was new to our adult learners. Although students were actively engaged in this exercise and tried to draw with exactitude, they were not necessarily trying to communicate something; the teachers were. The drawings strengthened our class discussion of the principle of variation.

In a second, active learning DTL exercise, we asked our students to create illustrations of a research design and the data it would yield (**Figure 2**). We set up, as a class, a simple study of the variables involved in radish seed germination and growth. The variables selected by the monastic students included light, temperature, and water. We then encouraged each of them to visualize the research process, draw it, and fill in a record of their investigation and data. The students created a variety of ways to illustrate the study, demonstrating the diversity of visualizations of their mental models. Each time they met with us to discuss their findings, we encouraged them to use their drawings to support the conversations. We found many students created matrices, often with illustrations of the treatments as cups (which we had provided to students to hold the soil and seedlings). Not only were these drawings intended to remind students of their experimental design, but drawings were also explanatory tools that could support student claims during discussions with peers and with instructors.

Drawing-to-Learn and Cultural Relevance

In the example of squiggle mutation, the drawing activity provided a visual to represent the instructor's conception. In the example of research design, students had the opportunity to share their own conceptions. Beyond 1) actively engaging each

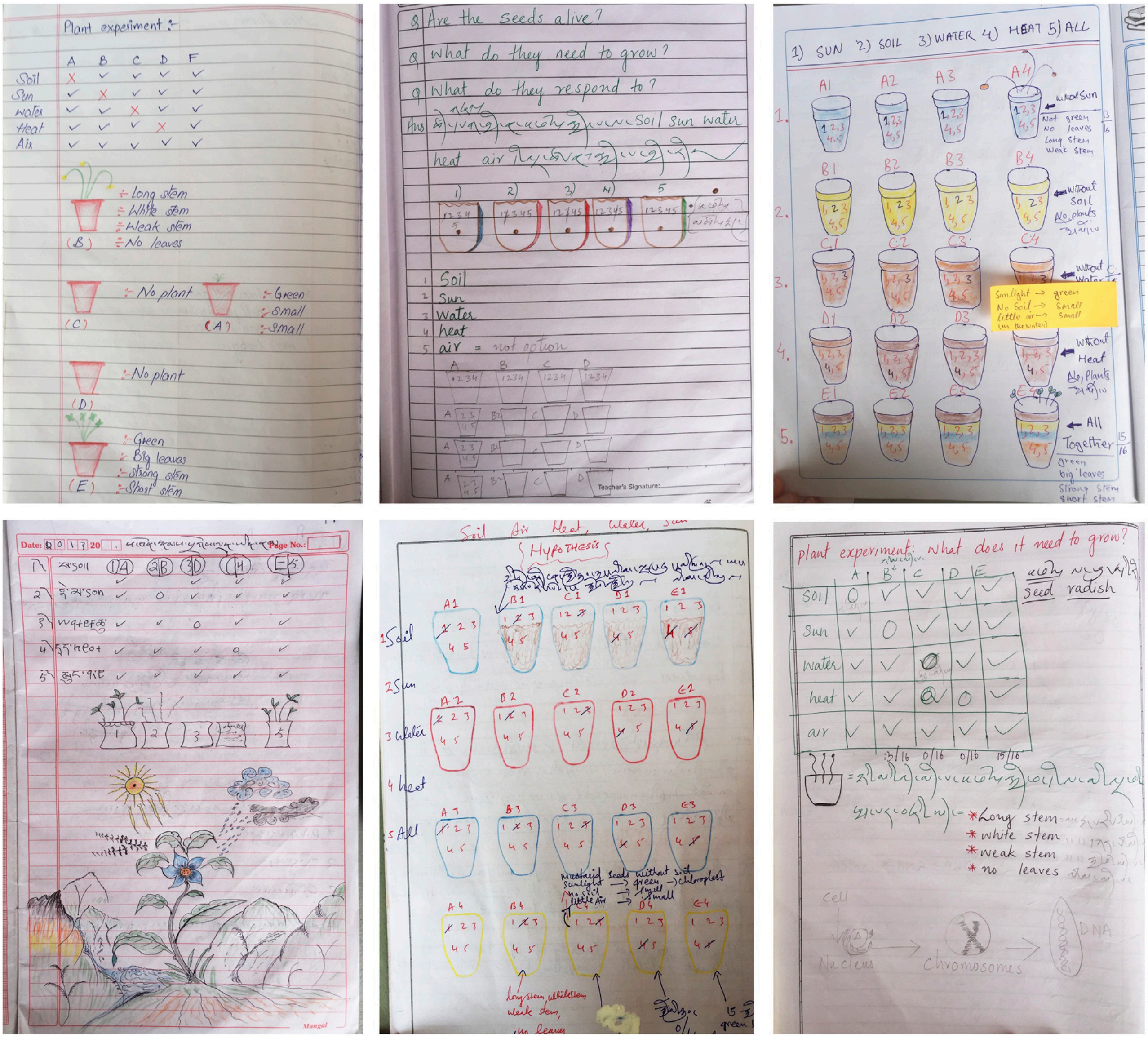

FIGURE 2 | A data visualization activity from six student's notebooks, representing a class study of variables affecting radish seed germination and growth. Student matrices were personally meaningful and distinct.

student and 2) concretizing their mental conceptions; however, DTL also 3) fosters multi-modal and culturally relevant communication. As students notice elements in their own drawings that reinforce or challenge their preconceptions of the natural world, the visuals can become focal points for written and verbal exploration in journals and with peers and instructors in the classroom. We have selected three examples of DTL fostering such discourse and moving students towards reconciliation between cultural/theological and academic/biological explanations.

Sperm and Sinboos

After a developmental biology lesson about sperm forming in the testes, multiple monks drew similar diagrams in their journals of a man's outline filled with sperm (**Figure 3A**). Examples were projected by a document camera on the board, so students could explain their ideas. We learned that many of the monks had been warned that during ejaculation, energy and power would drain from their bodies and minds (as evidenced by the whole-body lassitude felt beyond just the testes). Together, we reconciled different cultural and academic explanations by concluding that although swimming sperm were only generated in the testes, the nutrients for their formation, and that of the fluid semen, come from throughout the body. These drawings (**Figure 3A**) also sparked further discussion about small life forms, "sinboo" (སྲིན་བུ), including our human cells and bacteria that form microbiomes, that live in and on a person's body. The students described a common mealtime blessing recited in gratitude for

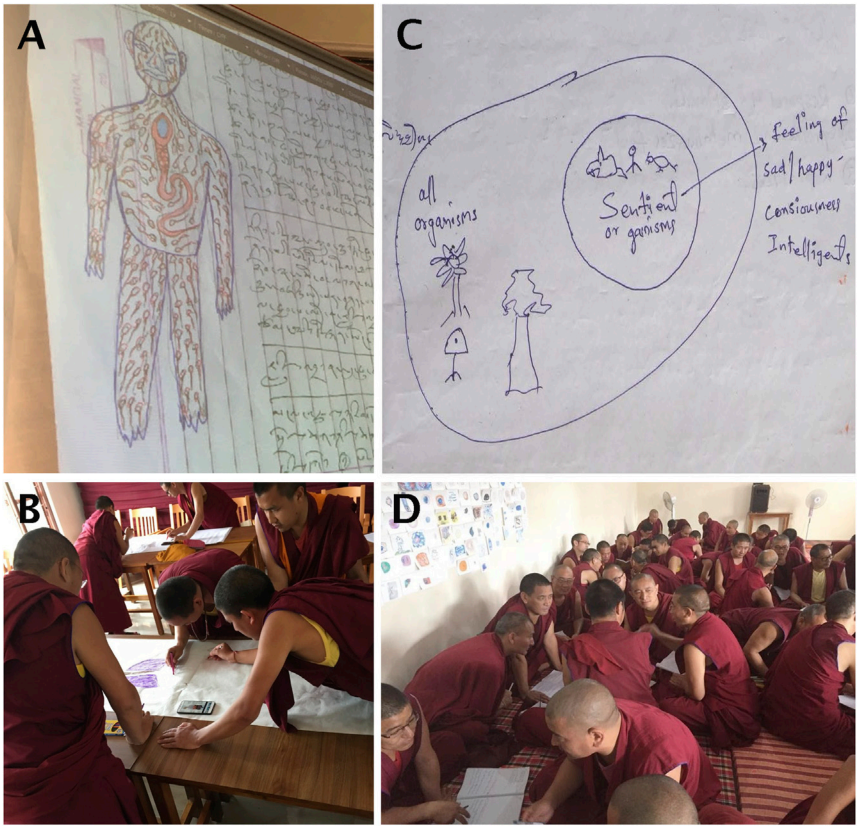

FIGURE 3 | DTL and culturally relevant ways of knowing in the biology classroom. **(A)** Journal drawing of sperm all over the male body. **(B)** Monks drawing life-size diagrams of the human body on butcher paper, using red/blue/yellow crayons to label the products of mesoderm/ectoderm/endoderm (the three embryonic germ-layers). **(C)** Journal drawing of a Venn diagram showing the monastic's distinction between living things and living beings. **(D)** Monastics using journal drawings as evidence during small group discussions.

the meal's nourishment helping not only the human body, but also many sinboo within, and dependent upon, that body. The monks expressed pride that Buddhists had known about such tiny lives before microscopes were invented and felt this to be an instance of satisfying overlap between biology and theology. The sinboo drawings were not intended to be observational but were conceptual and culturally meaningful to the students. While the instructors initially interpreted the drawings as misunderstandings, further discussion revealed that, in fact, there were deep commonalities and only superficial conflicts between the student's and instructor's ideas.

Two or Three Tissue Contributions

During a lesson on three embryonic germ layers (ectoderm, mesoderm, and endoderm), and which tissues originated from each, we (with co-instructor Christopher Brandon) asked monks to trace the outline of a classmate on butcher paper and fill it in using blue, red or yellow crayons to show the organs and structures produced by each germ layer (**Figure 3B**). We hung these colorful, life-size drawings around the classroom walls. Students commented repeatedly that the lesson on three germ layers differed from their previous conception of the body forming from two sources, male and female. For example, traditionally, they believed that bones and blood were contributed by different parents. As we became aware of this (two *vs.* three tissue origin) discrepancy, we asked the students to consider how their butcher paper drawings would differ, if based on the traditional rather than new teachings. The germ layer drawings led to an exploration of male and female contributions from multiple perspectives and brought cultural context into our science lesson (Fox Keller and Scharff-Goldhaber,1987). We found ourselves speaking with the students about the efforts of developmental biologists to form bi-maternal or bi-paternal embryos, and about the risk of presuming sperm cells to be active or masculine and egg cells to be passive or feminine (Martin, 1991). In this way, drawings extended our lesson to include how even scientists may be seeing cultural beliefs as though "they were part of nature" (Martin, 1991).

Living Things *vs.* Living Beings

During class discussions about the characteristics of life (e.g., organization as cells, genetic inheritance, ability to respond to stimuli), we (with co-instructor Nicole Gerardo) invited students to write and draw in their journals and then to discuss in small groups, while using their journal entries to support their arguments. One student used a Venn diagram in his journal to represent a distinction he found between all living organisms and those that are sentient (**Figure 3C**). When the journal drawing was recreated on the board, many other students agreed that all living things share characteristics, but animals remain distinct from bacteria, plants, and fungi, because animals are capable of self-awareness and suffering. The monks referred to animals as "living beings," while they called other organisms "living things." The drawing prompted a further discussion about whether or not awareness of one's own emotions is a defining characteristic of life (**Figure 3D**), and how to illustrate when this trait evolved. More importantly, this drawing allowed students and instructors to learn from one another and about the interplay between different types of knowledge.

DISCUSSION

The case study we share here on drawing-to-learn pedagogy in ETSI biology courses reveals benefits to the use of DTL in culturally diverse classrooms. Like writing-to-learn, DTL engages students in active learning and can support multi-modal (visual, written, and spoken) exploration of mental models. Beyond this, DTL also solicits cultural references from both students and teachers, allowing everyone to explore areas of reinforcement or dissonance between academic and cultural funds of knowledge (Balgopal et al., 2021; Moje et al., 2004). Given that one of the aims of the ETSI program is to foster cross-cultural understanding, especially as they navigated both theological and scientific teachings, we found that DTL was a particularly relevant pedagogical approach. DTL was also well-suited to the ETSI context because students were learning new and translated terminology, and because it complemented rhetorical strategies with which students were familiar. Dialectical debate is central to monastic education, and our students discovered that drawings could be used as supportive evidence during such discourse. In the process of meaning making during debates and discussions, monastic students could make links between academic and cultural concepts, or, other times, found resolution between disparate ideas by border crossing - moving between two ways of knowing (Balgopal et al., 2021).

Inspired by our experience with DTL as instructors in Buddhist monastic universities, we posit that DTL can be relevant across educational contexts. Visualizations of mental models reveal for both learner and teacher what is clear and messy, as students make sense of new concepts (Dikmenli, 2010). Both disorderly writing and drawing can reveal disorderly thinking. Teachers in all contexts need to assess learning, while guiding students. Drawings provide that needed window into student's minds. Every line in a drawing *tells*; every line makes an assertion and reveals a person's choices in assembling, interpreting, and using facts. The American adage "a picture is worth a thousand words" reminds us that drawings are distillates of sometimes wordy, inefficient, or obfuscating written text. Non-verbal representations can also foster communication, by initiating and anchoring verbal articulations. When journal entries contain both visuals and written text and are then further used in class discussions, they are naturally multi-modal (Kress et al., 2014; Park et al., 2020). Drawings make unique tools for in-class discussions, where they support problem solving in real-time and a shared space (Atkins Elliott et al., 2016). In short, tacit meanings are exposed, and "the viewer can be drawn into a dialogue with the image" and with peers and instructors (Rowsell et al., 2012, p. 447).

We extend Quillin and Thomas's (2011) list of DTL's benefits to include "uncover cultural knowledge." In this case study, we have demonstrated that DTL can help make cultural knowledge explicit and potentially help learners reconcile different worldviews, while informing instructors of where tensions or confusions (or just alternative conceptions) arise (e.g., Balgopal et al., 2021). Conceptual revelations may be even more important in situations when students and teachers may not be fluent in one another's primary language (Gray et al., 2020). Although our case study was populated with learners and teachers who brought very different types of knowledge to class discussions, DTL has broad benefits across a range of academic contexts. For example, science teachers across levels (primary to collegiate classrooms) are known to use metaphors and analogies to illustrate concepts to learners, but unless students have a chance to explore and visualize these, their interpretations may differ from those of their instructors (Duit et al., 2001; Brown and Salter, 2010). Other benefits of DTL include exploring temporal and spatial processes together, as a class. Often these processes are illustrated with abstract symbols (e.g., flow charts with arrows for the central dogma of biology) or as abstract images (e.g., stylized cartoon drawings of cell organelles). Yet, much of the research on this type of visual literacy continues to focus on how students interpret images, and not on how they convey their own conceptions through their own images (e.g., Schönborn and Anderson, 2006; McTigue and Flowers, 2011). We believe that DTL's utility for fostering bi-directional learning (between students and teachers) warrants further study.

We encourage biology instructors to explore creative ways of integrating DTL into their curricula, even in contexts with shared or similar worldviews. DTL reveals nuanced understandings of the natural world that students may not be able to articulate in written or spoken text and does so in an all-in-one, holistic product (Wilson and Rigakos, 2016). Alternatively, drawings can quite naturally accompany written and verbal assignments, allowing students to make use of multiple modalities. As seen in previous WTL studies, students who are given permission to share through class activities will reference unanticipated personal and cultural funds of knowledge (Balgopal et al., 2017; Chang, 2018). We acknowledge that our case study was limited by only examining the drawings of monks (when monastic students also include nuns), and by focusing on drawn artifacts and in class observations, rather than written artifacts and audio-recordings of monastics explaining their drawings (these are being analyzed for a different study). Nonetheless, our findings on DTL, as an active and culturally relevant teaching strategy remain.

In summary, DTL can provide both teachers and students with windows into each other's minds, can make the unseen seen, and can foster multi-modal discourse and integration of diverse conceptions of the natural world. Given that drawing is "generative and material; it calls forth the presence of the person who created it" (Fink, 2020) to bring special benefit to the biology classroom.

DATA AVAILABILITY STATEMENT

The anonymized data supporting the conclusions of this article will be made available by the authors, upon reasonable request.

ETHICS STATEMENT

This study involving human subjects was reviewed and approved by the Institutional Ethics Review Board of Colorado State University (protocol #053-16H). Written and/or oral informed consent was obtained from the participants for the publication of any potentially identifiable images or data.

AUTHOR CONTRIBUTIONS

Both authors conceived the study, collected and analyzed the data, and wrote the paper.

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The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2021.739813/full#supplementary-material

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Fostering Respectful and Productive Conversations: Lessons Learned From Debating Courtyards in Tibetan Buddhist Monasteries

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A suspicion for perspectives that differ from one's own is not new to human interactions. What is new, however, is the disregard and the resultant disrespect that colours mainstream discourse across the globe today, whether in the media or in person. This creates barriers to healthy interaction and hence to learning from collaboration. Our team comprises a Tibetan Buddhist monk, a writer, an editor, and a neuroscientist, and we hope this paper, guided and crafted by a regard for the diversity of our experiences across two continents, can demonstrate how respectful and productive conversations can be achieved. We begin by stating the need for forms of communication that are very different from prevailing modes of interaction. We then examine the mechanics of debate that form the foundations of communication and learning in Buddhist monastic communities and discuss how this form of debate can help us arrive at harmonious interactions. Finally, we propose a format for respectfully initiating, maintaining, and ending conversations that take place anywhere from the classroom to the boardroom and newsroom.

Keywords: conversation, respect, monastics, disagreement in conversations, principles of good conversation

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INTRODUCTION

Conversations these days reflect our socio-political reality—fragmented, polarised, distrustful, and disrespectful. The reasons for this are many—political demagoguery, religious xenophobia, aggressive sports, identity politics and media echo chambers—and these and other inflammatory social forces build upon and reinforce the "us versus them" mindset that is deeply ingrained into human social structures across the globe. This perfect storm of upheaval keeps us divided and steals opportunities for us to work collaboratively towards creating a safer and harmonious world for all. Our work has exposed us to a range of diverse experiences, from those of a Tibetan Buddhist monk learning the scientific method, a neuroscientist teaching his subject to Tibetan Buddhist monastics as part of the Emory Tibet Science Initiative, and of writing and editing literature through a multi-cultural lens. This wealth of experience has shown us the need to foster dialogue in the Tibetan tradition—respectful engagement with diverse perspectives, focused not so much on being right as on discovering what is right for all. We view collaborative and not partisan conversation to be part of that utopia and we use this writing to articulate why and how we can achieve the same.

CONVERSATIONS AS COMPETITIVE SPORT

Ideally, conversations with differing perspectives would be conducted in the manner of two respectful pugilists in the ring. They would greet each other at the beginning, pay mind to the rules of the sport, tease with their strengths while drawing out weaknesses, and each aim to achieve their goal slowly and by accumulating technical points for successive punches landed. Now, conversations resemble the chaos of modern boxing. They are loud, flashy, designed to overwhelm the opponent with bluster, and are often played short and only until one can land a knock-out blow, regardless of whether a point has truly been made or not.

THE GONPA AS A BENEVOLENT BATTLEGROUND

The debating courtyard of any Tibetan Buddhist monastery (a gonpa) in the evening is like a sea at sunset. It is colourful, calm and still on the surface, but it thrums with the often unseen and unheard movements of minds in motion with one another. Clapping, and even stomping, punctuate the indistinct murmuring. This often leads the brain into thinking one is in the expectant crowd gathering before a rally or concert, waiting for things to begin. Such aural confusion is reinforced by the sight of waves of monks and nuns in these courtyards, clad in their maroon robes as they undulate like gentle swells on their way in to the sands of serenity. Their traditions of debate date back centuries, and watching these scholars debate complex existentialist thought in a joyful and respectful manner is as revealing as a Sun rising over a dark ocean and lighting up their steps in the sand. It is in following in these footsteps that we believe the path to changing the tenor and outcomes of our contemporary conversations lies.

The way every debate begins is itself demonstrative of how antithetical this style is to current styles of discourse and why it might serve as the antidote we so sorely need. No matter whether the debate includes two monastics or whole debating "teams", every debate begins with དྷིཿཇི་ཐར་ཆོས་ཅན། (Dhee Jhe Tar Choe Chen), which translates into "Let us mover closer to the truth." After invoking this mantra, one member (or team) assumes the role of the defender of the matter being debated and sits, while the other remains standing and assumes the role of the challenger. And so, the debate begins.

The first thing that gets put away is ego, and the desire to move closer to the truth becomes the driving force of this serious and intense pursuit. Often, debates start with the clear defining of every component of the construct in question. This ensures that the grounds for debate are known to both parties, creating a clearly stated and agreed upon set of priors which can be discussed sans misinterpretation. The debaters then start challenging and defending their positions by employing logic and citing testimonial resources and references from their texts. If an agreement has not been reached at the end of this period of personal debate, many monastics tend to take the topic into group debates that begin right after the one-on-one debate has ended. If the groups and all their varied perspectives still cannot help resolve the debate, it is then presented to their teachers in pursuit of further clarification and eventual resolution. Debates can become heated affairs. Sometimes, debates are resolved and sometimes, both parties agree that there is a differing of their views which makes agreement not possible. But regardless of the end result, there is no winner or loser in this form of engagement. Only happy seekers of a truth that applies to all.

One of the more interesting aspects of the debate is the role that gestures play, each of which has its own significance. One of these occurs when one palm is slapped downwards by the other in a rapid cadence and the hitting palm then slightly withdrawn towards the body. This might sometimes be accompanied by a jump and/or a swivel. The slap of the palm is meant to signify striking a wisdom nerve in the hope that the challenger and defender receive wisdom. The downward motion symbolises closing the door to ignorance. The slight backward pull of the hitting hand serves as a reminder to open the door of knowledge, and to not hold on to opinions too tightly. Slight variations of these gestures and movements are a manifestation of that monastic's personality and it is heartening to see the debate leave room for personal expression.

But it isn't all fun and games at the gonpa. Debating monastics prepare rigorously. They read their scriptures, receive learning from their teacher, reflect over it, and then arrive at their own interpretation of the scripture. Fortified by this process, the monastic then enters the debate. Like boxers sizing up one another, the debaters spar and use their arguments as punches and counterpunches, but with one critical difference from the ring—there is no winner or loser at the end of this match. Instead, the monastics retire to their khangtsens (living quarters), where they reflect upon the debate. Then, they revisit both sides of the debate and refine their positions in preparation for a rematch the next day. However, there is one key difference here. In the next round, they swap positions! Yesterday's defender is today's challenger and vice versa. This forces the debaters to examine every aspect and angle of the same argument, exposing each of them to perspectives that they might otherwise not have encountered. Any dogma can now be dispelled and objectivity can now be pursued. This leads to a nuanced understanding of not only the topic before the debater but also the one sitting across.

Reading about the mechanics and interpretation of this tradition might leave one wondering about its utility. What, after all, is the purpose of a debate if not to change minds? Here, too, the underlying motivation to debate sheds light on its usefulness. The primary reason for engaging in debate is sharpening one's intellectual understanding of a certain concept so as to refine or restructure one's philosophical and spiritual knowledge of the concept and achieve spiritual growth. Never is it intended to pit winning against losing. Instead, it is designed and engaged in for the purpose of enriching logical understanding of concepts with depth and width of perspective. Through the exchange of contrary ideas about the concept that is being debated, the debate is considered to be an analytical meditation that one can use to build logical foundations to maintain or restructure convictions of philosophical concepts. This rigor also reinforces the importance of objectivity, a key component of fruitful and respectful debate. Using the building blocks of logic is an integral principle of the debate that serves to internalize and mold existing understanding of the concept into practical and transformative spiritual practices.

LEARNINGS FROM THE MONASTERY FOR A MODERN WORLD—CONVERSATIONS AS COLLABORATIONS AND NOT COMPETITIONS

To have an objective, respectful conversation is to come away from it with an expanded perspective that serves to educate and inspire oneself and those we engage with. It is worth noting that debate teams and clubs in Western society afford participants rigorous training in the discussion and defence of multiple positions on a given issue. In doing so, such debating teams and clubs allow us to hope that wrestling with diverse perspectives is both a possible and worthy pursuit. However, with less attention now paid in these venues towards maintaining objectivity and respectful dialogue while facing the headwinds of polarization outside their doors, the Tibetan debating system shines light to guide our path to this goal.

Surrender "Us Versus Them."

Divided as we are, we have been further polarized by the COVID-19 pandemic. These turbulent times have heightened the suspicions that many have of those who look, talk, dress, worship, and vote differently from themselves, giving rise to an unprecedented level of identity politics. In the United States, 64% of the population believes that inter-personal trust is declining, and 70% believe that this is a big hindrance to problem solving (Pew Research Center, 2019). One of the factors that builds up this mistrust is the egotism that can accumulate from an insular approach to life in our media, social and political bubbles. This approach makes us believe that we and our ways are superior to anyone else and theirs. If we learn from how Tibetan monastics shed their ego before they enter their debates, trusting the person across from us can become easier. We can then look to learn from everyone we meet and engage with since we discover that we are but one piece in the mosaic that is humanity.

Be Curious, yet Patient

The monastics are among the most curious students that our neuroscientist teammate has ever encountered. Their desire to understand the world around us better is deeply rooted in wanting to understand the causes and consequences of suffering with a view towards eliminating it. Driven by this lofty goal, they soak up every strand of information they encounter during the debate and weave it into their existing tapestry of knowledge. And to do so, they pay rapt attention to what is being discussed, listening more than speaking, waiting patiently for their turn to share their perspectives on the matters being discussed.

Prepare Rigorously and Objectively

Even if we choose one side of a debate, we should be prepared to argue both. Spend time reading and researching, engage with teachers, peers, and loved ones, and reflect on all one has heard and gleaned before entering the debate. This allows for a fuller immersion into the topic before we step into its waters. Delving deeper into both perspectives of a debate also allows for an objectivity that leads to a lack of attachment to one's position. While this lack of anchoring runs counter to how we are raised and how discourse is now conducted, it opens us to the objective truth and reduces subjective bias. Additionally, grappling with contrasting perspectives allows for a distinction to be made between the position being debated and making a value judgement about the person engaged in the debate. By doing so, we can create and hold space for those whose views differ from our own.

Disagree Respectfully

In the debating courtyards of the gonpas, there are no permanent positions in the pursuit of a destination. The challenger and defender exchange positions and accept any perspectives that help them understand their goal better. Attachment to one's ideas and aversion to other perspectives is forgone in the acceptance of one not possibly holding all the knowledge required to move closer to the truth on the topic being discussed. In the same way, we should remember to not be stubborn about our perspectives when debating because this can often lead to fractious engagement from which we gain nothing and only lose friends and allies. The monastics teach us two lessons that do not necessarily remedy disagreement but move us closer towards doing so. First, they lean into the discomfort of conflict knowing that it is a critical component of moving closer to the truth. By not fighting this disquiet, the ego is not stung by disagreement and accepts it as par for course. Second, the monastics accept that some differences are bigger than what the current conversation can address. From this perspective, they pivot to a collective effort and include more partners in their conversations either by way of bringing the disagreement to a group debate or seeking counsel from their teachers.

In conclusion, there is an immediate and critical need to alter the tone and tenor of our current conversations. The Tibetan system of monastic debate has the potential to show us how to arrive at harmony from our current cacophony. To bring the various pieces together into a symphony might be easier said than done. However, with intention and attention to its various parts as outlined above, we posit that we can create this music. Together.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

BGD conceived of the concept. LS, MD, ND and BGD wrote the article.

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Boundary Crossing by a Community of Practice: Tibetan Buddhist Monasteries Engage Science Education

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As a globalized world struggles with division and disinformation, engaging across difference has emerged as a major challenge to communication and collaborative action needed to address growing global challenges. As such, the initiative by Tibetan Buddhist leaders to incorporate western science in curricula for monastic education may serve as an important case study that illuminates the conditions and processes at work in genuine cultural outreach and exchange. That project, spearheaded in the Emory-Tibet Science Initiative (ETSI), involves reaching out across two quite different communities of practice, Tibetan Buddhism and science, and the willingness and ability of individuals to cross the boundaries between them. In the study reported here, we apply existing understandings of communities of practice and of learning mechanisms that mediate boundary crossing to probe for presence of conditions and processes that promote effective outreach among Tibetan Buddhist monastic students. We deploy analysis of qualitative survey, interview, and self-report data from monastic students shortly after ETSI began (2009) and after science education had been rolled out in the monasteries (2019) to, first, identify initial cultural conditions related to outreach and engagement with science, and, second, probe for post-rollout presence of boundary crossing learning mechanisms among monastic students which facilitate communication from one community of practice to another. We found a range of robust initial cultural conditions (e.g., perceived overlap in subjects and methods of inquiry), along with strong presence of mechanisms that facilitate boundary crossing (e.g., reflection, transformation) and operate through time. We observed cascading effects of these conditions and mechanisms on student engagement with science. Furthermore, interactions of these conditions and mechanisms allow monastic students to engage with science on their own Buddhist terms and to regard learning science as potentially beneficial rather than threatening to their personal or collective Buddhist goals.

Keywords: monasticism, cultural outreach, boundary crossing mechanisms, Emory-Tibet Science Initiative, science education, learning mechanisms, community of practice

INTRODUCTION

In January 2008, the Dalai Lama formally announced the launch of an initiative in monastic science education to an audience of over 30,000 monastic and lay attendees during a major teaching at Drepung Loseling monastery in India. The leading figure in Tibetan Buddhism within and outside Tibet, His Holiness articulated the rationale for this bold undertaking and placed the authority of his imprimatur on it. The announcement of the Emory-Tibet Science Initiative (ETSI) had been prefigured by decades of his own dialogues with western scientists, speeches to the monastic community about the value of engaging with western science, and various small-scale programs to teach science to monastics (Dalai Lama, 2004). The new initiative aimed to bring western science education into the mainstream of monastic curriculum itself. [Note: Here we abbreviate western science as "science" while recognizing the wealth of science systems across cultures (Janes, 1999; Zidny et al., 2021)].

Such a commitment to outreach by an ancient, prominent, and culturally and socially complex tradition such as Tibetan Buddhism to another powerful, similarly complex and established yet quite different tradition such as science rarely occurs and, sceptics might think, may put the host tradition at risk for irrevocable change. Existing research on communities of practice such as Tibetan Buddhism or science has identified conditions that drive their development and welfare (Wenger et al., 2002), while a related literature has identified mechanisms that mediate successful boundary crossing between communities of practice (Akkerman and Bakker, 2011). In this report, we begin by reviewing literatures on communities of practice and boundary crossing, the history of ETSI, and precedents for cultural outreach in Tibetan history, followed by rationale for the focus on monastic students in the present study. Then, we deploy analysis of qualitative survey, interview, and self-report data from monastic students to identify initial cultural conditions for outreach and engagement with science, and probe for presence of boundary crossing mechanisms that facilitate communication and exchange from one community of practice to another. Note that this study is partnered with a related quantitative study also included in this special issue.

In a globalized world that struggles with division and disinformation, engaging across difference has emerged as a major challenge to collaborative action needed to address growing global challenges. As such, the Tibetan Buddhist monastic establishment's project to engage with science may serve as a valuable case study that illuminates conditions and processes at work in genuine cultural outreach and exchange.

Boundary Crossing and Communities of Practice

Defining characteristics of communities of practice are that its members identify with a common purpose, interact constructively and often, and cultivate shared cumulative learning to pursue their common goals (Lave and Wenger, 1991; Wenger, 1998). By these criteria, the monastic communities in Tibetan Buddhism and in western scientific communities each represent recognizable albeit diverse communities of practice formed by distinctive purposes, interactions, and epistemologies that characterize members' identities, attitudes, behavior, and to a large degree, worldview (Hacking, 1983; Lopez, 2008).

Successful encounters between communities of practice involve boundary crossing, where the boundaries are not merely physical but also epistemological, behavioral, affective, and sociostructural (Shore, 1996). This is especially true where the community of practice is large, established, and essentially constitutes a culture or subculture. Social sciences investigation of boundaries and boundary crossing has intensified in response to escalating forces of globalization and social change alongside urgent needs for diversity and inclusion (Engeström et al., 1995; Lamont and Molnár, 2002; Akkerman and Bakker, 2011). A growing body of theory and evidence engages both ecology and processes of boundary crossing. Social ecology drives impetus and informs outcomes of boundary crossing that arise from contextual push/pull factors such as social structure (Friedman and Podolny, 1992; Soundararajan et al., 2018), resource demand and allocation (Hawkins et al., 2016; Risien and Goldstein, 2021), cultural forces (Denner et al., 2019), and power dynamics (Goldstein et al., 2017; Collien, 2021). History, too, plays a largely overlooked role (Ravishankar et al., 2013).

Boundary crossing processes themselves have been investigated as sites for learning (Walker and Creanor, 2005; Caruana and Montgomery, 2015; Boulton, 2019), collaboration and innovation (Carlile, 2004; Penuel et al., 2015), and organizational change and navigation (Walker and Creanor, 2005; Yagi and Kleinberg, 2011; Hawkins et al., 2016; Risien, 2019). Such processes appear central to education, particularly STEM education, where students and teachers need to develop skills to engage in scientific discourse within diverse communities, as well as the ability to leverage strengths of collaborators' multiple perspectives (Austin, 2018). Integrating multiple worldviews in the learning environment has been associated with increased number and diversity of STEM graduates, better learning in the classroom, science experimentation, discovery, and knowledge, and ultimately more creative and skilled scientists (Hartfield-Méndez, 2013; Bouncken et al., 2016; Jackson et al., 2016). Facilitating boundary crossing also has proven useful for establishing continuity between the teaching community of practice and education researchers (Bakx et al., 2016).

This expanding body of work suggests that boundaries are inherent features of human social life that can serve as learning resources, rather than as barriers to productive engagement (Collien, 2021; Leach, 2001; Risien and Goldstein, 2021). Findings highlight boundary crossing as essential to learning (Akkerman and Bakker, 2011; Wenger-Trayner and Wenger-Trayner, 2015), and distinguish key elements of boundary crossing processes, namely agents, objects, and mechanisms. Agents, or boundary spanners, come in many guises, including as internal actors negotiating exchange (Thomas, 1994; Sturdy and Wright, 2011), or mediators of task orientation or socioemotional connection (Friedman and Podolny, 1992; Weerts and Sandmann, 2010), or power brokers who leverage conditions for engagement and innovation (Ryan and O'Malley, 2016; Collien, 2021; Wegemer and Renick, 2021). Boundary objects have been recognized to play crucial roles as mediating entities that bridge communities of practice by being legible for all participating communities while also sufficiently multivalent to represent internal value for each (Star and Griesemer, 1989). As co-constructed community-bridging artefacts, boundary objects can be material (documents, physical spaces), abstract (ideas, neologisms, norms), behavioral (rituals, practices) or animate (transdisciplinary student). Hence, "creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds" [(Leung, 2020), *p*. 3]. As such, boundary objects have been closely studied as powerful agents in knowledge-sharing and collaboration (Carlile, 2004).

Learning may involve boundaries, but how is their learning potential realized? A review of learning-focused studies that examined boundary crossing has identified four mechanisms of learning that underlie boundary exchange—identification, coordination, reflection, and transformation (Akkerman and Bakker, 2011, see also **Table 2**). Each class of learning mechanisms comprises distinct processes. In the first, identification, boundaries between practices become uncertain or destabilized through two processes, othering (sharpening contrasts) and legitimating coexistence (identity redefinition, boundary reconstruction). The second, coordination, allows diverse practices to cooperate efficiently in distributed work through three processes: communicative connection (exchange, translation), increased boundary permeability (smoother interactions), and routinization (automatization, normalization). The third, reflection, involves realizing and explicating differences between practices in order to learn about one's own and others' practices via two processes, perspective making (delineating one's perspective) and perspective taking (seeing the other's point of view). The fourth, transformation, entails collaboration and development of new practices, effecting social change that involves six processes–confrontation (recognizing a conceptual or pragmatic gap that requires both parties to re-evaluate existing practices), recognition of shared problem space (shared concerns), hybridization (create new cultural forms), crystallization (reification, institutionalization in new practices), integrity maintenance (sustain uniqueness of the intersecting practices and thus, boundary crossing), and continuous joint work at the boundary (required to maintain productivity of boundary crossing).

Subsequent research has applied the Akkerman and Bakker schema for mechanisms of boundary crossing for many purposes, including production and evaluation of educational programs (Leung, 2020), math teacher training designing research-practice partnerships (Fjørtoft and Sandvik, 2021), and serious game design (Delima et al., 2021). Here, we apply it to analysis of monastic students' reports about engaging with science.

The Emory-Tibet Science Initiative

In 2006, the Dalai Lama and Emory University forged a partnership to establish western science education in Tibetan Buddhist monastic universities. During the 2008–2013 development phase, teams of western scientists iteratively prepared and tailored a multi-year program with curricula in areas monastic leaders considered most relevant for Tibetan monastics. In 2013, leaders in the dominant school of Tibetan Buddhism, the Gelugpa, decided to implement the resultant science program, ushering in the most substantial curricular innovation in 600 years of monastic education. Consequently, the 6-years science curriculum comprising biology, neuroscience, and physics and supplemented by math and philosophy of science, was introduced that year in intensive summer programs at the three largest monastic universities of south India (Gray and Eisen, 2019). Implementation of the roll-out was completed in Summer, 2019, by which time science education was institutionalized in participating universities, the monasteries took over science education, and ETSI transitioned to a sustainability phase focused on building in-house capacity for science pedagogy and research (Worthman et al., in press).

The science initiative constitutes cultural outreach, wherein the monastic community invited the western scientific community to share concepts, methods, and knowledge without expectation that, reciprocally, the scientific community must engage seriously with Buddhism. Western scientists were requested to represent the scientific fields on their own terms, rather than try to adapt scientific disciplines for exchange with Buddhism *per se*. Monastics aimed to learn core logics, practices, key concepts and insights of the focal fields–physics/cosmology, biology and neuroscience–while the science educators sought to present them as clearly and accessibly as possible (Worthman et al., in press). Yet more was expected than lectures, lab exercises, and vocabularies. Tibetan Buddhism is a text-based tradition, from the recorded collection of the Buddha's teachings through centuries of written commentaries and revealed teachings (*terma*). As such, ETSI was asked to produce texts that provide a basis for teaching and study. Hence, ETSI faculty wrote a series of 16 condensed texts, or primers, one for each of the 5 years of the curriculum in each of the three disciplines, plus one for philosophy of science. Throughout, translators played key roles, working with ETSI faculty to produce a science lexicon in Tibetan and mediating communication in classroom and texts. All texts comprise facing pages of corresponding Tibetan and English content. These materials, together with rapid turnover of science education to the monastic universities, served as important boundary objects and created a basis for the monastic community to learn, critically engage with, and intellectually process science on their own terms. The goal was not necessarily to produce monastic scientists, but science literate monastics who could engage with science on an equal intellectual footing.

In sum, the ETSI spearheads a Buddhist-initiated collaborative project with western science for knowledge transfer toward sustainable science literacy in the monastic community that will provide grist for thought and analysis, and charge examination of modes of inquiry and knowledge production with an aim both to advance development of

Buddhism and to enhance its value for all sentient beings. His Holiness the Dalai Lama jokingly has remarked that the project would proceed quickly and take merely a hundred years or so.

Cultural Outreach and Innovation in Tibetan History

Engagement by Tibetan Buddhism with western science has firm historical precedents. Tibetan history is distinguished by signal moments of cultural outreach that have had defining impact on the course of Tibetan society (McKay, 2003). Such turning points go back to the 7th Century with first formation of an expansive centralized state under the Tibetan King Songtsen Gampo, who introduced Buddhism to Tibet and sent a minister, Thonmi Sambhota, to India, thus initiating centuries of contact with major centers of Buddhist scholarship there (Dreyfus, 2003; Van Schaik, 2013). In the 8th Century, another Tibetan King, Trisong Detsen, brought eminent Buddhist scholars, including Shantarakshita, abbot of Nalanda University, the seat of Buddhist scholarship in India, and the formidable guru Padmasambhava, to establish Buddhist practices and monasticism in Tibet. Emissaries also were sent to India to learn Sanskrit and translate Buddhist texts into Tibetan, resulting in production of the Tibetan alphabet and script orthographically adapted to the Tibetan language, as well as a formalized grammar (Shakabpa, 1984). Among their major effects on Tibetan society and culture, these innovations permitted translations of Buddhist texts with extraordinary fidelity to the originals in Sanskrit and Pali. A second major wave of Indian Buddhist scholars was ushered in during the 10th Century, whereafter Buddhism in India declined and was largely expunged by the 14th Century. Consequently, Tibet became the center of Buddhism in central Asia (Mongolia, Bhutan, Nepal, some of Russia and India) (Vleet, 2015). Many foundational Buddhist texts wiped out in India became available only in Tibetan under their monastic stewardship, and a flourishing Buddhism was institutionalized in Tibet to form a vast monastic establishment with distinctive schools, scholastic lineages, and practices that generated the rich corpus of Tibetan Buddhism (Snellgrove, 1995; Kapstein, 2006).

Active outreach by Tibetans also advanced development of a powerful Tibetan medical tradition, *Sowa Rikpa*, by recruiting input from major traditions elsewhere [(Gyatso, 2015), *p.* 105–8]. The Tibetan king, Songtsen Gampo, invited eminent medical practitioners from India, China, and Persia to share with local clinicians and distil their knowledge into texts that formed a comprehensive compendium of disparate medical systems (Tsultrim and Dakpa, 2009). A century later, Trisong Detsen famously brought prominent physicians representing three major medical traditions–Indian, Chinese, Graeco-Arabic–for an international conference (Gyamtso, 2017). Thus, evolution of Tibetan medicine drew upon medical knowledge and practices from India, western Asia, China, and its own indigenous shamanic traditions, while it also proceeded in close conversation with evolving Buddhist thought about the body, perception and affect, ethics and karma (Gyatso, 2010; Ga, 2014).

From these roots, Tibet emerged over centuries as the leading heir and guardian of the classic Indian Buddhist tradition and holder of a sophisticated medical system with widespread influence (Kapstein, 2006). The Chinese invasion and occupation of Tibet truncated this history by 1959, with an intent to destroy Tibetan culture (Shakya, 1999; Shakabpa, 2010). Ironically, the takeover also created a Tibetan diaspora that prompted global dispersion of Tibetan Buddhist monastics who fueled widespread interest in the tradition's highly developed ideas and practices (Zablocki, 2017). The Dalai Lama, head of the Gelug lineage and of the Tibetan government in exile until 2012, became a global figure engaging in teachings, conferences, and humanitarianism (Puri, 2006). Reciprocally, the Tibetan Buddhist community encountered novel systems of thought including western science. Out of personal interest, the Dalai Lama pursued decades of dialogue with western scientists and concluded that, in many significant respects, Buddhism and western science share common purposes and complementary perspectives (Dalai Lama, 2004). Consequently, the introduction of western science in Tibetan monastic education was inspired by his vision for comprehensive science education at Tibetan monastic universities which would foster informed engagement by his community. Once again, a Tibetan head of state charted a course of cultural outreach, this time by bringing in scientists to share knowledge and modes of inquiry.

Boundary Crossing in Monastic Science Education

The engagement of Tibetan Buddhist monastic education with western science commits to a dynamic evolution of its established community of practice. Although Tibetan history provides strong positive precedents for benefits of cultural outreach, the present initiative raises interest in whether and how it might succeed. Social science insights about processes of boundary crossing offer concepts and frameworks to address these questions, in terms of key mediators: boundary objects, boundary spanners, and mechanisms.

Boundary Objects in the ETSI

Boundary objects serve as powerful engines for boundary crossing by mediating iterative cycles of situated learning that generate social structure bridging communities of practice (Wenger-Trayner and Wenger-Trayner, 2015). From its inception, the ETSI invested heavily in co-production of boundary objects to scaffold monastic science education. These included the series of bilingual primers on each of the target disciplines written by teams of scientists and translated by Tibetan translators. This required *de novo* creation of a Tibetan science lexicon, because the relevant terms were absent in that language (see details in Samphel et al., in this issue). Both ongoing processes have taken years and involve intense collaboration between and among scientists and Tibetan scholars. The summer science sessions held annually during the 12 years of pilot and roll-out phases also were co-produced by teams of scientists who created written curricula and then taught it in India, together with Tibetans who translated written materials as well as in-person lectures and activities. All worked to revise materials iteratively across successive years of implementation. Cumulatively, 418 faculty were sent to India during the 6-years implementation phase alone, and annual monastic student enrollment reached 1,500 by conclusion of that phase. Moreover, by this time all three participating monastic universities had built and staffed science centers with teaching and research facilities.

In sum, by completion of the roll-out phase in 2019, a wealth of boundary objects (bilingual books, online science curricula and teaching materials, a rapidly growing Tibetan dictionary of science, and monastic university science centers) had been co-constructed through the concerted efforts of both monastic and science communities.

Boundary Spanners in the ETSI

As the previous section implies, the ETSI involved many active boundary spanners in the Tibetan monastic and western scientific communities. Within the monastic community, premier among these was the Dalai Lama himself who paved the way and prompted the initiative, even participating as inaugural speaker at the 2005 annual Society for Neuroscience meetings. Two of his close associates, Geshe Lobsang Tenzin Negi at Emory University and Geshe Lhakdor at Library of Tibetan Works and Archives in Dharamsala, India, work tirelessly for monastic science education, raising awareness, funds, logistics, and institutional involvement in both the U.S. and monastic communities. Identification and training of monastic students to spearhead science education was built into ETSI: the two cohorts of monks who participated in the pilot phase had been selected as strong scholars and potential leaders in monastic science education. Many of these went on to become science teachers, translators, and program leads at the monasteries and elsewhere. In addition, funding from the Dalai Lama Trust created the Tenzin Gyatso Scholar program that brings successive cohorts of monastics to Emory for 2 years of intensive science training. These Scholars have become central figures in the roll-out of monastic science education and its transfer to the monasteries themselves. Then there are the Tibetan science teachers and translators in India and the U.S. who are building the science lexicon, translating texts, and mediating direct exchanges between Buddhist monastics and scientists.

A flourishing literature by those engaged at the boundary of Buddhism and science includes books by the Dalai Lama himself (Dalai Lama, 2004), scientists who trained in Buddhism [e.g., (Wallace; Revel and Ricard, 1998; Dreyfus, 2003; Varela et al., 2016)], and scientists who have taught Tibetan Buddhist monastics (Impey, 2014; Eisen and Konchok, 2018). We have heard little from the monastics themselves [but see (Eisen and Konchok, 2018)], particularly from the monastic students. This likely will change as more reports emerge from diverse sources (see other articles in this special issue), and this report contributes to representation of the monastic community in ongoing discourses about engagement between Buddhism and science. Moreover, recent studies in boundary crossing emphasize the importance of all members of the community, of social dynamics, relationships, and the individual point of view. A review of change in higher education identified the need to go beyond structure and leadership to consider values, preferences, and goals that drive actions and relationships of participants (Kezar, 2014), while study of research-practice partnerships has identified the importance of graduate student perspectives (Wegemer and Renick, 2021).

We recognize that boundary crossing is dialogic, reciprocal, and evolves through time. The above background sections aimed to provide framing on cultural outreach and engagement with science by the Tibetan Buddhist monastic community historically and in the ETSI. In the present report we focus on perceptions and attitudes of monastic students in the ETSI program. After all, students are the crux of education. Although they are decisive factors in success of any program of learning, their voices are too seldom heard.

Study Aims

Our goal in this study is two-fold, first to identify attitudes and expectations about implementing science education among students in the Tibetan Buddhist monastic community, and second, to assess the bases for potential success of this project of cultural outreach from assessment of cultural frames and learning mechanisms for boundary crossing among Tibetan Buddhist monastic students. To address these aims, we use qualitative analysis of survey data collected at the early formative stage of the program in 2009 (Time 1) and focus groups, audio journal recordings, and interviews collected 10 years later, in 2019 (Time 2), after the full science curriculum had been implemented in the monasteries. Thematic analyses of Time 1 survey responses probe for initial presence of shared cultural affordances (attitudes, values, modes of thought and learning) related to engagement with science. Application of the Akkerman and Bakker boundary crossing framework to focus group, audio journal, and interview data gathered at Time 2 evaluates prevalence of the four boundary crossing learning mechanisms, namely identification, coordination, reflection, and transformation (Akkerman and Bakker, 2011). Throughout, we include quotes from the monastic students to illustrate and interpret our findings, and to give primary voice to the Tibetan Buddhist monastic community: after all, engagement with science is *their* project. Note that monastics are highly articulate; any roughness of quotes in English is due to translation.

METHODS

Participants

Monastic students enrolled in science education at the monasteries are adult learners with a well-developed cognitive frame and are already scholars themselves. They enter the science curriculum after completion of at least 10 years of Buddhist study and 3 years before starting exams for their advanced *geshe* degree, and thus have a deep grounding in Buddhist scholarship. Their ongoing Buddhist studies and monastic duties occupy much of their schedule, such that science education diverts time and attention from these demands.

Time 1. Respondents comprised 32 monastics in the first cohort enrolled in the ETSI program, including 28 monks and 4 nuns; age mean 32.8 ± 5.3, range 20–42 years; birthplace: Tibet 72%, 22% India, 3% Nepal, 3% Bhutan. They were advanced

Buddhist students and scholars nominated by their home institutions and selected for both enrolment in the pioneering phase of developing formal science curriculum for monastic education, and to act as leaders in science learning in their monastic community. All were pursuing formal Buddhist studies at monastic universities or institutions, having completed 16.2 ± 4.7, range 9–26 years of formal Buddhist education, excepting 2 monks who had completed advanced monastic degrees. Participants varied in previous science exposure in workshops or short courses, averaging 2.5 ± 2.9, range 0–9 prior experiences.

Time 2. Participants comprised 15 monastic student volunteers from Drepung and Gaden Monastic Universities who either were interviewed individually (n = 4) or completed an audio journal (n = 11). Seven of the audio journal group further participated in a focus group. Participants spanned the entire 6-year monastic science curriculum, from first- (n = 6), second- (n = 1), and third-year (n = 5) science students to graduates of the initiative (n = 3). All were male (monastic universities are exclusively male), ages 28–37 years, and in the 18th–23rd year of Buddhist studies. They had varied degrees of experience with summer intensive science sessions and/or year-round classes at the monastery. Participants differed in attendance at pre-monastic schools, with five out of seven focus group members having received formal education before joining the monastery and the other two beginning their education within the monastery school. Hence, this very small volunteer sample was somewhat diverse but unlikely to be fully representative of monastic students at all participating monasteries.

Preliminary focus groups. At the outset of ETSI in 2008, four focus groups were held to discuss science education and relationship to Buddhist views with 19 members of the first ETSI cohort whom senior monastics also had identified for parallel participation in a leadership program. All also participated in the Time 1 survey.

Procedures and Data

Time 1. In June 2009, at the start of the neuroscience segment for their second year in the summer pilot program of ETSI, students enrolled in the first cohort completed a written structured open-ended survey of attitudes and expectations about science, specifically neuroscience, and its relevance for them. Responses were written in Tibetan and thereafter translated to English by professionals fluent in Tibetan and English who also translated in ETSI classes. For the present analysis, two of the authors (ACK and CMW) coded responses to the following questions in the survey: "Why study neuroscience?", "What can science discover that Buddhism cannot?" and "Might they collaborate?" The first question was coded on two dimensions, subject matter (mind/consciousness, brain/nerves/senses/transmission) and intellectual interest (knowledge/understanding, relevance or comparison to Buddhism), while the other two were coded for content (nothing, material evidence, common interests, collaboration/complementarity). Content of a response might be coded on more than one dimension. Coders had high agreement for identifying codable chunks (99%) and good agreement for coding by category (93%). Disagreements were resolved through consensus.

Time 2. In December 2019, after the roll-out of the science curriculum in the monasteries was completed, seven monastic students participated in a 2-h focus group discussion about science education at Drepung Monastery conducted in English and Tibetan and co-facilitated by two of the authors (KMG and TL, also a Tibetan-English translator). Two days after the focus group, audio journal prompts were sent to 11 monastic student volunteers, including the seven in the focus group and another four students who were not able to attend the focus group. Audio journal prompts were posed in English and Tibetan both in writing and verbally. Student responses were approximately 5 min long, spoken in Tibetan, and collected over several days. Four volunteers from the first-year science class (n = 201) participated in the individual structured interview. Individual interview, focus group, and audio journal prompts (See **Supplementary Material S1–3**) span a range of topics including attitudes about science before and after exposure to it, impact and relevance of learning science, and comparison of Buddhism and science.

All recorded materials (interviews, focus groups, and audio journals) were transcribed for coding on references to boundary crossing learning mechanisms. The long narrative formats required a more complex analysis than the brief survey responses at Time 1. We used a thematic analysis approach (Braun and Clarke, 2019) to analyze the qualitative data (127 statements from 15 students). TL, RW, and KMG generated initial definitions of each learning mechanism using (Akkerman and Bakker, 2011) with minor adjustments for cultural appropriateness. ACK completed an initial coding; each statement was coded as reflecting one or more mechanisms or as Other (not applicable). CMW conducted a coding consistency check (Thomas, 2006) using the same codebook. ACK and CMW then reviewed any disagreements and came to consensus on a final codebook (definitions in **Table 2**) and the coding of all statements. Further peer checking involved coding the interview transcripts and later meeting to discuss and justify themes and text segments. Coders had good overall agreement (81%) and good agreement for coding by category (82%). Intercoder agreement increased the reliability of our interpretations, despite having only two researchers involved in the data analysis process (Creswell and Crewswell, 2017). Codable material contributed by participants varied widely: mean number of codable comments per person was 8.3, range 4–23.

RESULTS

Here we first present findings related to each of the two study aims, namely to identify cultural frames, attitudes, and expectations regarding implementing science education in the Tibetan Buddhist monastic student community, and to tap presence of learning mechanisms for boundary crossing among students once the program was rolled out. We report coded material with quotes from 2009 to 2019, complemented by

TABLE 1 | Initial attitudes about engaging with science, particularly neuroscience.

Frequencies represent a count of responses that used a related word or concept (n of respondents = 32)

Domain	Response	Count	Example
Why study neuroscience?			
Subject matter	mind/consciousness	15	*"To know about the relationship between cognition and consciousness." "To find the absolute relation between neurons and consciousness."*
	brain/nerves/senses/transmission	16	*". . . to know about internal functions of the body and also the transportation of information from the body to the brain." ". . . to see how our brain functions and how it controls our body, . . ."*
Intellectual interest	knowledge/understanding	19	*"Neuroscience is the only subject which comes nearest to what its already taught in Buddhist text, especially on the functioning of the sensory organs and how to recall and retain memory and so on. To understand better on these issues from the modern explanation I study neuroscience."*
	relevance or comparison to Buddhism	13	*"There are certain issues that is contradicted while many others that is complemented in Buddhism from science, so to know these things I study neuroscience."*
What can science discover that Buddhism cannot?			
Discovery	Nothing	11	*"As told in Buddhism there is nothing that Gautama Buddha didn't know and he didn't practice." "There is nothing that science can find and Buddhism cannot. But what ever they find could be different from each other."*
	material evidence	19	*"Science has been able to discover all those external knowledges and tools which Buddhism cannot." "Science can discover on the external physical things . . ." "Science works on external world while Buddhism focuses on the internal mental level."*
Might they collaborate?			
Discovery	common mission or subject	16	*". . . might help us in understanding how consciousness arises and so on." ". . . science alone cannot solve all those questions on mind so they can help each other mutually." "reduce suffering"*
	collaboration/complementarity	30	*"Yes they have to collaborate because it is beneficial to both." "Buddhism has been able to provide many fields for neuroscience to work on and at the same time, the findings from them have been able to provide a platform for Buddhism." ". . . science brings out the empirical findings while Buddhism answers these more logically."*

few select quotes from 2008 focus groups. Because 2008 transcripts are partial and all participated in the 2009 survey, only quotes particularly illustrative of themes documented in the coded material are included.

Time 1. Cultural Frames and Initial Attitudes Among Monastic Students Toward Science Education

Monastics endorsed the value of a firm foundation in Buddhism before studying science. As one student observed: ". . . we normally think that science and religion [are] very different and are contradictory. . . . First we need to know our own religion so we can analyze how science is and then we can define if they are contradictory." Although Buddhism and western science are distinct traditions, we asked whether there might be cultural conditions in Tibetan Buddhist monastic culture that support boundary crossing and cultural outreach with equanimity toward their possibilities for generating internal change if potential benefit is perceived.

Why Study Neuroscience?

Students' survey responses cited both subject matter and intellectual interest as prime motivators for studying neuroscience (**Table 1**). They highlighted the overlap in objects of inquiry for Buddhism and neuroscience, although the purposes of inquiry differ. Buddhist theory and practice aim clearly to understand operations of the mind and consciousness as well as perception and the senses (Dreyfus, 1997), because: "ultimately the mind is the root of everything that's there in the physical world and beyond." Indeed, "The most important characteristic of mind is to be able to engage with unlimited number of objects and when this engagement is guided through a right path then it leads to understanding of infinite knowledge." Hence, monastic study and discipline aim systematically to cultivate deep understanding and mental training so that "by knowing the mind and mental factors, one should be able to remain calm" and develop most fully the mind's ability "to engage with any object and also improve or develop infinitely".

A majority of survey responses expressed interest in learning specifics about how the brain and body function, and their relationship to consciousness. Buddhist texts provide detailed accounts of sensory perception and cognition, and relations of cognition to behavior, but mechanistic accounts of neurons, neurotransmission, and brain function are novel. Thus, study of neuroscience may help "understand better these issues from the modern explanation" with a view toward further understanding mind if neuroscience can help track "the absolute relation between neurons and consciousness." Allied with monastics' intellectual curiosity and interest in new knowledge from science, was a frequently emphasized intent to compare and contrast scientific accounts with their own Buddhist-informed understandings in order to evaluate and sharpen those understandings. For instance: "To see how neuroscience and Buddhism compliment and contradict each other, especially on mind and mental processes."

Similar to monastic practices of extensive debate to hone understanding of Buddhist thought (Dreyfus, 2003), study of scientific material and critical scrutiny in juxtaposition with a monastic's current views may provide grist for development of those views toward a more accurate understanding of things as they are. "So, in this way science can answer many questions for monks in Buddhism and it is important to have an understanding why and what can be the difference and we can think about these results." Monastics expressed confidence that their years of grounded training in logic and critical analysis of concepts and evidence would be powerful tools for engaging effectively with science and deriving benefit if it were there to be found: "In Buddhism there are various texts or tenets that [are] used where we have to use our logic and our minds to study, and in science also we have to use our minds, and so it is helpful to have a chance to learn science and we can correlate them."

What Can Science Discover That Buddhism Cannot?

Responses reflect Buddhist epistemology that buddhas are omniscient; hence, the principled reply by a third of respondents was: "Nothing." (**Table 1**) Given a view of the mind's capacity for infinite development and knowledge if properly trained, as the Buddha's was, it is in principle possible to know anything science can discover, and much more. Thus: "Science is a minute physical entity and a part of Buddhism". That such enlightenment is excruciatingly rare, opens wide a window for critical engagement with new forms of knowledge that advance the core Buddhist project for enlightenment, for one's own or other scholars' understandings may be limited or faulty. This critical stance is a core tenet of Buddhism: "And the Buddha said you don't have to take my words out of respect for me. You need to check it out for yourself and if you find something wrong, then don't accept it, even if it is said by me. So that is the backbone of Buddhism so there is no reason for not learning science." This stance informs monastics' view of the relationship of scientific to Buddhist knowledge: "There is nothing that science can find and Buddhism cannot. But whatever they find could be different from each other."

Consequently, although a third of respondents said nothing new could come from science, two-thirds endorsed the value of material evidence that science produces with sophisticated methods and tools, citing the scientific focus on the external or material physical world in contrast to the Buddhist focus on internal or immaterial mental realm. These positive responses highlighted that Buddhism and science share a common mission to reduce suffering along with common objects of inquiry. Scientific evidence was valued also because it might advance Buddhist scholarship, for instance it ". . . might help us in understanding how consciousness arises and so on."

Might They Collaborate?

Given their views on complementarity of foci, methods, and goals in science and Buddhism, nearly all respondents roundly endorsed the potential value of collaboration between them (**Table 1**). None expressed perceived threat from studying science *per se*, although competing time demands were an issue; rather, monastics expressed excitement about the intellectual stimulation, valued the potential for advancing their own development, and foresaw a possibility that new questions and insights might emerge from such critical engagement. As one of them noted: "They have to collaborate because neuroscience explanation is highly related or closely related to the understanding of consciousness. So the knowledge from both sides have to come together and maybe we will find a third area to work on."

Time 2. Boundary Crossing Learning Mechanisms in a Community of Practice

Coded statements from focus group, audio recorded responses, and interviews in 2019 yielded counts of how frequently monastic students invoked boundary crossing learning mechanisms when talking about their interactions with western science education. Monastics often spontaneously alluded to these learning mechanisms, suggesting that conditions for boundary crossing in Akkerman and Bakker's schema were being met (**Table 2**). Specifically, each of the four domains appeared in a substantial portion of coded statements, and at roughly the same frequency. By contrast, endorsement frequencies for subdomains under each of the four mechanisms varied substantially. Responses invoking specific mechanisms in each learning domain are characterized below.

Identification

Monastic students expressed identification in their othering statements ("contradictory to the Buddhist understanding of how the cause give rise to effect") and legitimating coexistence ("this makes sense and reasonable") comments. Reflexive thought related to legitimating coexistence was observed as frequently as othering statements in transcripts (**Table 2**). This may be due to the monastic commitment to egolessness and robust training in analytic thinking that reflects on interdependence.

Coordination

Coordination was observed most frequently in remarks regarding communicative connection, here construed as effective communication ("Before I learn science, I never thought math is needed." "After learning science . . . complete new knowledge."). Frequencies for some mechanisms within the domain of coordination varied widely (**Table 2**).

Reflection

Respondent's statements robustly demonstrated reflection, representing the views of western scientists on their own terms (perspective making; "Through engagement with science, I know the nutritional value of those foods that I have been ingesting.") and were only somewhat less likely to empathically consider scientists' views with Buddhist views in mind (perspective taking; "I realized that there is comparative learning between the science and Buddhism.").

Transformation

Evidence of transformation was observed in confrontation of views ("I am learning Buddhist student, we can say that we disagree with evolution theory. We say it is fate which brings the animal to this environment."), and to an even greater extent in the recognition of shared problem space ("These mathematical expression seemed to have some relation to Buddhist concept such as bodhicitta mind."). Interestingly, hybridization or integration of different bodies of knowledge is mentioned as often as is confrontation, again related to respondents' Buddhist training both to critically engage any given view and to seek resolution through examination ("I think if we collaborate two

TABLE 2 | Domains and related mechanisms involved in boundary crossing between communities of practice.

Domain frequencies represent a count of utterances that referenced any constituent mechanism in that category. Mechanism frequencies represent number of utterances referring to that mechanism. (respondent* n *= 15; utterances coded* n *= 127)

Domain	Mechanism	Definition	Count	Example
Identification		Apply personal and conceptual work to encounters between traditions	80	
	Othering	Characterize one tradition in terms of another, based on distinctive features and points of difference	39	*“If one is really dedicated to finding the truth through the scientific method it takes a lot of time and a lot of effort. . . . Buddhist study itself is very rigorous, so there is no time to take part in this kind of research.”*
	Legitimating coexistence	Validate and accommodate both traditions	41	*“. . . if we Buddhist and we Biology science just* [complement] *each other also develop in this world . . . many, many beneficial.”*
Coordination		Cultivate means and conditions that promote effective cooperation among diverse practices, even if consensus is absent	74	
	Effective communication	Exchange impactful information, as noted in before/after comparison by respondent	40	*“Before I learned, all I understand about visual perception is from the Buddhist text. . . . After learning science, light reflection playing role . . . photoreceptor playing role . . . signal transduction . . . perception. Complete new knowledge.”*
	Translation	Clarify distinct views and concepts, in both literal and subjective senses	11	*“. . . though the term “living being” is being used by scientists and Buddhist people, the way the term is defined in each is different. . . . In Buddhism, when we talk about living beings we are talking about . . . having consciousness. . . .On the other hand, when we talk about science, living beings have these seven characteristics. . . . Initially, it was challenging to accept this.”*
	Increase boundary permeability	Facilitate fluid cross-boundary action and exchange	18	*“. . . if the scientists and the Buddhists each have their own methods of analyzing an object, if these two methods of analyzing the same object can come together then it could create something more. And called this bridging.”*
	Routinization	Normalize cooperation and habituate to exchange	5	*“Whenever there are new terms in science or English, he always takes notes. He takes a small notebook in his pocket. He always carries that small notebook. Whenever he has chance, he always read, take it out from the pocket and he read and learn some new words.”*
Reflection		Understand and articulate both practices and reflexively deepen understanding of each	76	
	Perspective making	Articulate personal understanding of a concept or domain	43	*“Science is a study using physical material. Evidence-backed experiments that are not driven by religious dogma or national, patriotic feelings. . . .Totally unbiased and experimental way which is supported with a lot of evidence. That is a method of experiment. Evidence.”*
	Perspective taking	Empathize with others’ views by reflexively considering one’s own	33	*“The way science and Buddhist text talked about experiment are something we could compare. . . .*[S]*cientist use previous finding by the different scientist to examine with re-experimentation. . . . Likewise, the previous . . . realization in Buddhist text are not to be taken granted but rather subjected to thorough investigation using experiment.”*
Transformation		Effect substantive change in both communities	85	
	Confrontation	Consider a conceptual or pragmatic gap that requires both parties to evaluate existing practices	22	*After learning a bit about brain (CNS and PNS), and comparing that with Buddhist, we say it’s consciousness, but neuroscience may not. However, neuroscience did lot of research on the brain . . . those are fact, but if all body and everything is controlled by just brain, this is little difficult to accept.*
	Recognizing shared concerns	Identify a mutual concern to tackle cooperatively	28	*“Science is . . . based on experiments using physical materials; now . . . science is going to inner science which talks about mind. This is where Buddhist science comes into play.”*
	Hybridization	Combine elements to realize new insights or practices, on the personal or cultural level	20	*“These mathematical expression seemed to have some relation to Buddhist concept such as bodhicitta mind. I think there might be able to prove it also using math. Saw huge potential in helping society.”*
	Crystallization	Integrate substantive changes in the practice	0	Not observed

(Continued on following page)

TABLE 2 | (*Continued*) Domains and related mechanisms involved in boundary crossing between communities of practice.

Domain frequencies represent a count of utterances that referenced any constituent mechanism in that category. Mechanism frequencies represent number of utterances referring to that mechanism. (respondent* n *= 15; utterances coded* n *= 127)

Integrity maintenance	Maintain core elements of each tradition while cultivating hybridity at the boundary	5	*". . . scientist give credit to the pioneer and father of those knowledge...even though those finding may not hold true. . . . I find it interesting as from Buddhist student. It actually motivated me to find the sources in my field even more than ever."*
Continuous joint boundary work	Sustain engagement to achieve ongoing exchange	10	*"Nowadays everyone is everyday living with the science. Unlike earlier time where people did not have scientific knowledge. Finding the truth takes twenty or 30 years. It's a long process to reach the truth."*

field, it might help the society"). Analogous to routinization, crystallization involves a substantial shift in existing practice resulting from boundary crossing and exchange and was not observed in our data. Routinization and crystallization must be established through upstream processes of accommodation on personal and institutional levels.

Boundary crossing to science is barely approaching the point where there is a perceived need to maintain uniqueness of the monastic community of practice. Rather, the importance of time for science studies and the need for sustained boundary work and exchange were endorsed by the monks ("So that it is very important that you [western science teachers) come here and we all just, you come here." "It's a long process, to reach the truth."). Respondents pointed out that monastic universities have invested in science centers that act as sites for this work, highlighting the value of these boundary objects.

Non-Linear Progression in Boundary Crossing Between Communities of Practice

Our observations indicate that boundary crossing mechanisms operate dynamically in a process that develops through time (Risien and Goldstein, 2021). Mechanisms related to early stages of boundary crossing were frequently mentioned, while those related to long-term change (crystallization, integrity maintenance, continuous joint work) were mentioned rarely or not at all. The ETSI program is young. Introduction of the science curriculum began in summer 2014, and many participants in this study had begun science studies just recently. One might expect identification, especially othering, to prevail in early boundary exchange. Further, one might expect reflection only after an extended period. Interviewee responses suggest that importance of each mechanism may vary with duration of exchange (translation: "Initially, it was challenging to accept this . . ."; continuous joint work: "Nowadays everyone is everyday living with the science."), community characteristics (othering: (Buddhist study itself is very rigorous . . .")), and ability to establish common ground (boundary permeability: "And I think these two schools have to collaborate because even though there are some minor differences but there are many complementing areas in both.") Translation and boundary permeability were especially salient when monks experienced challenges to effective science communication in the classroom or with accommodating science studies in their other studies and commitments. ("If one is really dedicated to finding the truth through the scientific method it takes a lot of time and a lot of effort. Even if they (monastic students) want to do that kind of research, they are unable.") Statements from students in the monastic community of practice reflected a view of science education as a work in progress, both for themselves and at institutional and cultural levels.

DISCUSSION

The present study responds to the historic decision by the Tibetan Buddhist monastic community to introduce western science in their monastic university curriculum. This move resonates directly with similar acts of cross-cultural outreach that had tremendous impact in Tibetan history, including one that fueled the formation and rise of Tibetan Buddhism and another that founded Tibetan medicine. In each case, Tibetan leaders acted as culture entrepreneurs who reached out internationally to secure input from the top thinkers and practitioners in a field. Tibetans thereafter actively worked with the input to develop their own rich and effective traditions of thought and practice, and demonstrated leadership, agency, and creativity in charting the course of Tibetan culture in the vital domains of spiritual and physical well-being.

Daring as the decision to introduce western science might appear, our data from monastic students identified a range of factors that support its soundness, including cultural conditions, mechanisms that facilitate boundary crossing by communities of practice, and a cascade of effects that devolve from both of these. Initial cultural conditions and attitudes identified at Time 1 include perceived overlaps in subjects and methods of inquiry. Monastics highlighted their interest in mind, body, all sentient beings, cosmology and matter that overlap with areas of scientific inquiry. They also appreciated scientific methods of rigorous inquiry, skepticism, repeated observations, independent inquiry and empiricism, and minimization of bias that were similar in spirit if not in detail to Buddhism. Further, they valued the empirical information from science that illuminated structures (e.g., neurons), mechanisms (e.g., neurotransmission, sensation) and processes (e.g., memory, vision) that were hitherto unknown or explained in different terms in Buddhism. Yet they also emphasized the need for critical evaluation of this information as they would any evidence in Buddhism, *via* reflection and debate.

They further noted that such evaluative processes would provide grist for monastic study and debate comparing and contrasting accounts in science and Buddhism. Lastly, the theme of complementarity ran through student responses, including notions that interaction of Buddhism and science might produce new questions and possibly open new modes and fields of inquiry.

Monastics' view that the purview of science was narrow compared with the expansive one in Buddhism may contribute to the absence of perceived epistemological threat or concern about dominance from science in remarks by these Buddhist scholars. Yet, while a third of respondents said there was nothing that science could learn that Buddhism could not, they consistently endorsed the possibility of seeing the same things differently, demonstrating again their openness to complementarity and potential collaboration.

Prevalence of boundary crossing mechanisms among participants' remarks in 2019 provides robust evidence both that these mechanisms are in operation, and that their importance in the process of boundary crossing changes through time. Monastics spontaneously and frequently expressed mechanisms of identification, coordination, reflection, and transformation. That maintenance of community integrity and joint work rarely appeared and crystallization not all, strongly suggest that the process was in its early stages. Although these observations would need to be tested in a larger, more systematic and representative sample, it is suggestive that the boundary crossing schema was fully manifest in these data, and encouraging that boundary crossing mechanisms were so actively present.

Taken together, the data suggest four inferences regarding reception of science education among monastic students, discussed in the following sections.

Core Elements of Buddhist Thought and Practice Provide Strong Affordances for Open Engagement With Science Despite Differences in Traditions

Across time, monastic students persistently reported reasons for engaging with science, both early and late in the process of developing and implementing science education for monastics. They emphasized shared objects of inquiry; note, however, that our 2009 data largely concerned neuroscience which they considered directly pertinent to their focus on mental phenomena and mind-body relations. They also expressed intellectual interest in new knowledge as tools for thought and inquiry to expand their current Buddhism-based understandings, and anticipated the possibilities for comparing material in the two traditions.

Monastics pointed to many areas of Buddhist epistemology and monastic training that prompted these attitudes. We highlight four here. First is an emphasis on independent observation and testing over received wisdom, which they see as having parallels in scientific methods: "methods adopted by the Buddhism and the science for investigation, they are similar. In science people don't believe what everyone says, they have to check it for themselves and they need to do the experiment for themselves and see the reasons so then they believe what other is saying." Second, is a rigorous search for truth with the aim to minimize bias and a willingness to discard what is refuted. One student cited the Buddhist maxim that ". . . one who does not believe in truth is not a wise man. You have to go with the truth no matter who you are. No matter who you are, if you are away from the truth, you are wrong. Any concept that is not true must be eliminated so as in science we can establish truth so they are parallel." Correspondingly, 10 of 31 responses to a 2009 survey question about the purpose of science specifically cited "truth" as a goal, and thus congruent with Buddhism.

Third is a set of powerful intellectual affordances cultivated in monastic training, comprising the vast Buddhist literature allied with rigorous training in logic and critical inquiry to both deploy and interrogate that literature. Thus: "Science is much, much easier than Buddhism. In Buddhism we have so much to memorize. . . . you have to think a lot and use your logic. The teachers in Buddhism don't give you the answer and you have to find it yourself. There is no possible way to find answers from the physical things like books." Through this process, monastics master the resources and skills to take on arrays of new ideas and information. "It is a part of our tradition in Buddhism that whatever we learn we debate with others and we try to convince others with reason and logic and textual information, so this is in our tradition when we learn science. . ." Fourth is a set of cultural affordances grounded in a view of radical uncertainty prompted by tenets of inherent ignorance and illusion with the aim to eliminate both, combined with an aim to incorporate interdependence and impermanence as existential givens. Given such profound challenges, monastics know the work will take a lifetime and more, and are open to valid means for speeding their path toward enlightenment: "It's a long process to reach the truth." Cooperation is essential: for instance, "Debating is key to understanding Buddhist concepts."

Monastic Students Recognize These Affordances as Situated in a Distinctively Buddhist Frame

This point was consistently supported by the monastics' written responses and verbal observations. As could be seen in the previous section, monastics framed the bases for engagement with science in terms of the concepts, skills, and methods of Buddhism. One might expect that they would do so at this early stage, but importantly, they clearly see grounds for engagement as located within their own tradition rather than as requiring them to step outside or discard elements in their community of practice. Right intention is key: "Nothing [is] wrong with science by nature so it is up to practitioners to use it in the right way or wrong way. It is the same way for religion also. It can be misused or used [for] the betterment of living beings. . ."

From a Buddhist perspective, the scope of phenomena tackled by science is relatively narrow. Monastics view Buddhism expansively, as affording the means, or path, to attain a complete account of phenomena across all time and space. Someone who eliminates problematic mental states such as anger or desire, and removes cognitive distortions by expunging the illusion of permanence, selfhood, and attachment to conventional reality, then may realize absolute truth and omniscience. Monastics regarded the purview of science as related to a significant but minor portion of Buddhist pursuits, as follows: "I believe that science is a part of Buddhism, Buddhist concepts. When we talk about Buddhism we can make it into 3 stages, the physical level of whatever is truth, then the path which is a different thing and then the result of that path is called the Buddhahood. When science is concerned, it is concerned about the basic truth of the physical thing." Monastics agreed that discovering those "basic truths" about physical realities is important for well-being, but they also point out, and scientists would certainly agree, that they do not address everything that matters. Buddhism has developed tools for exploring realms that science does not or does poorly: "In science you need material things but in Buddhism you have your own equipment, your hand and your mind."

This Buddhist Frame Makes Space for Critical Engagement

Monastic students use this space to advance their Buddhist understanding, which frames the project as a positive gain for monastics as individuals and as a community. Monastic student responses largely endorsed this point, albeit wiMonastic students use this space to advance their Buddhist understanding, which frames the project as a positive gain for monastics as individuals and as a communityth a caveat. Given the Buddhist presumption of inherent ignorance and the commitment to mental transformation, monastics were highly attuned to possible limitations or distortions in their knowledge and understanding. One wrote that: "The most important is to know what you don't know already." Alongside their formidable body of Buddhist knowledge, training, and skill, they readily entertained the need and possibility for further learning and development. They appreciated when learning science transformed their understanding of basic relevant phenomena such as sight, light, or matter: "Before I learned, all I understand about visual perception is from the Buddhist text.... After learning science, light reflection playing role . . . photoreceptor playing role . . . signal transduction . . . perception. Complete new knowledge." Hence, they expressed that scientific knowledge and methods might contribute to their understanding of important issues, although only after close critical scrutiny. For instance, monastics repeatedly noted the lack of an adequate account of consciousness in neuroscience and considered theirs as a very different view ("... science is unable to integrate the physical material with consciousness." ". . . when we talk about consciousness it is a different thing, a different level." ". . . also in Buddhism we can go to the minute level. Science doesn't go down to this level."), yet remained open to finding value in scientific attempts to understand it. One monk intended to ". . . understand these [physiological] mechanisms and simultaneously to compare this information with that taught in Buddhist texts on consciousness and subtle wind energy." In such endeavors, they plan to use the tools developed in Buddhist training to critically evaluate science and selectively integrate insights deemed valid and useful, rather than simply appropriating or rejecting it. "... I learnt about the way science do experiment, it's very systematic and the benefit of studying science is that we get new ideas. It reinforces the way we study Buddhist philosophy. The ways science and Buddhist text talked about experiment are something we could compare. By doing so, it helps us."

Hence, respondents regularly observed that learning science offers potential benefits for their Buddhist pursuits. ". . . the scientists and the Buddhists each have their own methods of analyzing an object, if these two methods of analyzing the same object can come together then it could create something more.... Is it possible to have this kind of research?" Note that monastics considered their engagement with science as being on an at least equal footing, and generously pointed out that "... science alone cannot solve all those questions on mind so they can help each other mutually."

Nevertheless, student willingness to find space for critical engagement is mitigated by constraints and possible areas of conflict around pursuing science studies that monastics pointed out both in 2009 and even more in 2019. As noted earlier, monastics' studies are demanding and their schedules very full. Study of science necessarily takes time and attention away from strictly Buddhist pursuits. One said that: "Basically, I don't have much time for . . . learning science. Because I have Buddhist philosophy classes. I have to go to lecture and debate and prayer and all of this." Another shared: "... if [a student] is not interested it is not useful, I think.... First we must understand the benefit." Buddhists regard attainment of a human life as a rare, precious, and all-too-brief opportunity to work toward enlightenment. Distracting from well-marked routes on the path may seem a hindrance unless one sees the benefit in terms of advancing one's own progress or, better yet, pioneering a path that may yield benefits for others in future. After all, the ultimate purpose of pursuing a Buddhist path is to benefit all sentient beings, and western science may or may not advance it.

Nested Factors Operate in Boundary Crossing by Monastic Students

Prevalence of disposing conditions at Time 1 and boundary crossing mechanisms at Time 2 suggest there are nested factors that might foster Buddhist monastic student engagement with science and ensure benefits for the monastic community and beyond. In the first of these nested factors, student responses invoked core elements of Buddhist thought and practice as providing strong affordances for open engagement with science, starting with common interests and values. They consistently linked Buddhist training to their interest in, appreciation of, and expectations for engagement with science. For instance, they regarded their Buddhist grounding in independent observation, dedication to rigor, and emphasis on testing and verification from multiple vantages as directly applicable to, and sympathetic with, scientific values and methods. Additionally, they considered the skills in Buddhist logic, debate, critical inquiry, and reframing of personal understandings that they developed through monastic training, as resources to be used in their studies of science. In particular, the cultivated openness to intellectual challenge and to new information relevant to their Buddhist pursuits added to the pleasure and stimulation that many reported experiencing in science studies. The new information that scientific research and technology could provide on subjects of common interest was valued by many of our monastic interlocutors, stimulated by Buddhist recognition of ignorance and sensitivity to the possibility that one's own knowledge and views are limited or erroneous: "There can be things that an individual Buddhist practitioner cannot find yet it can be discovered through scientific processes."

The second set of factors scaffolds the first: monastics grounded their engagement with science within their Buddhist scholarship, recognizing the aforementioned affordances as situated in a distinctively Buddhist frame. Note that they cast the interests, skills, and approaches that animate their science studies in Buddhist terms. Their openness to scientific knowledge, ideas, and methods was grounded in Buddhist values and epistemic practices. The sense that science might amend or advance but would not compete with or displace Buddhist scholarship arose from a view of Buddhist knowledge as all-encompassing whereas that of science as limited to material, measurable things, a relatively narrow purview. This widely shared view was succinctly captured here: "There is nothing that Buddhism cannot find but science has." This places science within the wider Buddhist enterprise, and contributes to the consistently expressed sense of openness and absence of threat or defensiveness about engaging with science. As one monastic wrote: "There are more reasons to continue this collaboration than not to continue it."

The third set of factors scaffolds the previous ones, for monastics' comments indicated how Buddhist teachings and practices open space for critical engagement with science that monastics use to advance their Buddhist understanding. For example, one observed that "findings done by neuroscience in a very empirical manner fill in some of those missing parts in Buddhism." Indeed, right intention to benefit Buddhist knowledge and understanding itself can justify engagement with science. Monastics' drive to improve their understanding was allied to a primary Buddhist goal to benefit others. "... I think it will be beneficial to all sentient beings if we can bring together neuroscience and Buddhist science to try and find out the relationship between meditation practice and behavior of the neurons. How far it is beneficial."

These stances frame the project as a positive gain for monastics as individuals and as a community, as well as for their wider mission universally to reduce suffering. "At this moment, Buddhism have been able to provide many fields for neuroscience to work on and at the same time, the findings from them have been able to provide a platform for Buddhism."

In sum, the attitudes, observations, and motivations expressed by monastic students engaged in learning science manifested a set of cultural conditions, mechanisms for exchange, and nested dynamics in Buddhist thought and practice. These illuminate grounds for the Tibetan Buddhist monastic community's engagement with science and augur for its success. In this case, "success" would mean enrichment of Buddhist thought and practice through an open-ended developmental process driven by the monastic community toward as yet undetermined but likely path-breaking outcomes in future. Within social scientific understandings of boundary crossing by communities of practice as a complex, multilayered enterprise, the individual merits more attention. We hope that insights generated by attending to monastic student voices in this instance illustrate the value of that approach.

Limitations and Future Research

This qualitative study is based on data collected with different goals in mind and thus has substantial limitations of design, interpretation, and generalizability. First, different methods of data collection were used at Time 1 and Time 2, which precludes direct comparison over the 10-year period. The entire class was surveyed at Time 1, but Time 2 was a pilot study involving volunteer participants in the focus group and audio prompt responses, with a very small and self-selected sample not necessarily representative of Tibetan Buddhist monastics. While it is intriguing to see that the boundary crossing schema was reflected in our 2019 data, we emphasize that the small sample and post-hoc nature of the analysis require future work with a larger representative sample to see if the schema remains useful. Given our observation that boundary learning mechanisms vary over time and operate synergistically, such a study might recruit equal numbers of students from each year of the science curriculum. Alternatively, a longitudinal study following students through all years of science study could directly observe boundary crossing learning experiences over time. Further work on boundary crossing could probe variation among monasteries and Schools in Tibetan Buddhism and track institutional change through time.

Future work would require creation of survey and interview questions specifically designed to investigate presence and direction of boundary crossing learning mechanisms, and increase generalizable understanding of dynamics in communication across communities of practice. Formal methods of instrument construction and translation should be used. The written survey instrument used at Time 1 was translated directly from English to Tibetan and neither back-translated nor subjected to cognitive testing (Van Ommeren et al., 1999). Similarly, translation of responses at both times was direct only. At Time 2, prompts were communicated to students by English-Tibetan translators, raising the possibility of inconsistency in definitions, conceptualization, and interpretation of terms. Equivalence is difficult to achieve even when questions are generated and responded to in the same language and similar cultures (Limeri et al., 2020), more so when multiple languages are involved.

Contributions of this study to the literature on boundary crossing are limited in several respects. Most prominently, only views of monastic students are represented. Members of the rest of the monastic community (faculty, administration, other monastics) should be engaged in future studies. The same is true of the western scientific community. Although the latter already are more well represented in publications, they also are thinly represented in empirical social science research. Second, boundary spanners and particularly boundary objects are known to play crucial roles in boundary crossing (Carlile, 2004; Thomas et al., 2007; Leung, 2020). We refer to them at the outset, but work with them is needed to build a rigorous understanding of this case of boundary crossing. There is some urgency, as time is passing and the project moves forward, suggesting that the moment to tap starting conditions and processes is now.

Lastly, the process of Tibetan monastic outreach to science would merit rigorous long-term cultural analysis, particularly of models and schema (Shore, 1996; Weller, 2007). Our data were not designed for this and were unsuited to such analysis, but our array of coding-based findings suggest this is an important area for research, perhaps by the monastic community itself. Impact of science education through time, its distribution and evolution within Buddhist scholarship, and many other questions about cultural and institutional change would merit investigation. The aspirations of monastic education diverge sharply from those of traditional western education. Tibetan Buddhist monastic education equips students to pursue a path of self-transformation toward attaining enlightenment, a process usually taking many lifetimes. In traditional western education, learning and earning degrees often are directly tied to career prospects and financial security. Hence, study of the project to include science in monastic curricula could yield profound, novel insights into education as well as culture change and adaptation.

Implications

Engaging across difference has emerged as one of the great challenges of the 21st Century even as globalization and media have removed barriers to communication. Increasing numbers of communities and even nations have suffered displacement to life in diaspora, as have many Tibetans and much of the Tibetan Buddhist community. Incorporation of science education in Tibetan Buddhist monasteries is a tremendous cultural project that directly affects the next generations of monastics and will ramify through future monastic scholarship and discourse. Our findings from monastic students identify shared features of Tibetan Buddhist thought and practice (e.g., critical thought, openness to change, cooperation) that both motivate and support this work, and may serve as inspiration for other forward-looking efforts in crossing boundaries by communities of practice, even very established ones. Proactive outreach to science by Tibetan Buddhism may serve as a case study for a middle way that combines cultural adaptation with maintenance of tradition as a path to cultural survival or, more than that, flourishing and growth. We close with the Dalai Lama's words on this matter:

> *"Our community shall not remain as it is. There will be changes. . . . The knowledge of science will be instrumental in the preservation, promotion and introduction of Buddhism to the new generation of Tibetans. Hence, it is very necessary to begin the study of science."* (Dalai Lama, 2000).
>
> *"A note of caution is called for, however. It is inevitable that when two radically different investigative traditions like Buddhism and neuroscience are brought together in an interdisciplinary dialogue, this will involve problems that are normally attendant to exchanges across boundaries of cultures and disciplines."* (Dalai Lama, 2005).

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Board of Georgia State University. Given the de-identified and archival nature of the data, an informed consent process was not required.

AUTHOR CONTRIBUTIONS

All authors listed have made substantial direct and intellectual contributions to the work, and approved it for publication. Specifically: Study concept and design: all authors. Data collection in 2009: CW, and in 2019: KG, TL, RW, and GG. Data coding and analysis TL, RW, KG, CA-M, AK, and CW Writing: CW and KG with feedback from all authors.

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Language, Truth, and Pedagogy

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Early in the planning the Emory-Tibet Science Initiative, we realized that the encounter between Buddhism and contemporary science demanded that Buddhist logic and epistemology encounter Anglophone philosophy of science. A titanic clash of world views was anticipated, but as we began the conversation, we found something different. Many philosophical concerns were shared, but these problems were understood differently. While fundamental elements of epistemology, like observation and inference, had similar functions in both traditions, subtle differences in conceptualization challenged mutual intelligibility. Through thousands of years of erudite debate, each tradition had honed their tools. While each cut cleanly, they carved in different joints. This essay will briefly discuss the linguistic, philosophical, and pedagogical adjustments that made for mutual comprehensibility.

Keywords: philosophy pedagogy, philosophy of science, buddhist logic, epistemology, translation

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INTRODUCTION

It was afternoon, and the ceiling fans swirled the wet, pre-monsoon air through the white-walled classroom. I stood with my shirt clinging to my back, while the monks looked comfortable, sitting cross legged and attentive on their cushions. The goal of the class was to explain Popper's conception of falsifiability, wherein a hypothesis is tested by looking for circumstances where it would be false. Falsification draws its force from a form of logical inference, recognized by the ancient Greeks and known to European logicians by its Latin name, *Modus Tollens.* My American students had always grasped this idea quickly, so I had not prepared a lengthy explanation. Instead, I wrote my stock example on the chalkboard, intending only to remind the students of a familiar form:

If it is raining, the streets are wet.
The streets are not wet.
Therefore, it is not raining.

I was utterly dumbfounded when the monks—who were never shy about raising objections or counterexamples to what I said—refused to accept that the conclusion followed from these premises. Having written a whole book on the possibility of alternative forms of rationality, I had optimistically thought that deep problems of translation could be overcome. Now, the project of the Emory-Tibet Science Initiative seemed about to run aground on the shoals of mutual unintelligibility. After an hour and a half of intense debate, the monks remained unconvinced. I went to a bookstore in Dharmsala, purchased Stcherbatsky's two volume *Buddhist Logic*, and began studying.

Navigating Similarities and Differences

The foregoing events occurred while Dr. Risjord was teaching in the pilot program of Emory-Tibet Science Initiative (ETSI). Since the philosophy of science was the first subject taught in the program, the exchange occurred during the first contact between Emory faculty and Tibetan monastics. When planning for the ETSI, we realized that the encounter between Buddhism and contemporary science demanded that Buddhist logic and epistemology encounter Anglophone philosophy of science. We anticipated some clash of world views, and worried about incommensurability. But, happily, Dr. Risjord's experience was not the opening round of a titanic and intractable debate. We found that mutual comprehension was possible, but we faced three sources of difficulty. First, while the respective traditions engaged with closely related epistemological concerns, there were important differences in how they understood the problems. While those working in each could appreciate the kinship of their concerns, it was important for productive engagement not to gloss over these differences. Second, substantial similarities sometimes hid deeper conceptual differences. Fundamental elements of epistemology, like observation and inference, had similar functions in both traditions. But the concepts had been developed in different debates, and their consequences were subtly different. As will be developed below, the concept of validity, as opposed to soundness, while central to scientific testing, proved to be foreign to, or problematic within, Buddhist epistemology. Finally, those conceptual differences were encoded in technical philosophical terminology, which meant that translation of apparently cognate terms could be quite deceptive. To surmount these, we needed both pedagogical and translational innovations.

The point on which Dr. Risjord was stuck illustrates all three dimensions of the challenge. The monks were suspicious of *Modus Tollens* for two reasons. First, they doubted the truth of the first premise. After all, there are conditions when it is raining and the streets remain dry; a canopy might protect the street, for example. And without true premises, they would not grant that the conclusion followed. Second, they thought that the argument was missing a premise, or at least left something implicit in the first premise. As a form of argument, it failed to yield a valid cognition.

While there may have been some indirect contact between the earliest Indian and Greek philosophers, the Buddhist and Western logical traditions developed independently and along somewhat different lines.[1] One of the differences lies in their understanding of the function of inference. What is good inference *for*? In the Buddhist context, good inference generates knowledge and well-constructed inferences lead to certainty. While the early Greek philosophers shared this idea, logic and epistemology began to part ways in the medieval and early modern periods of European philosophy. Mathematics developed in Europe in ways that had no parallel among Buddhist scholars, and European logic became closely associated with mathematical reasoning. This ultimately led European logicians to make a sharp distinction between *validity* and *soundness.* To say that an argument is valid is not to say that the premises are true. It is only to say that *if* the premises are true, the conclusion must be as well. From the European point of view, then, the falsity of the premise of Risjord's argument is beside the point when gauging its validity. On the other hand, a sound argument is one that is valid and has true premises. To be sure, only sound arguments can generate knowledge *of themselves*, but the soundness of an argument is not something that logic can determine. Hence, logic alone, according to European philosophers, cannot of itself produce knowledge about the world. That granted, within the Western tradition, the formal validity of an argument with a false premise could serve in a wider inquiry that did generate knowledge about the world. The point is pivotal in an understanding of scientific testing. A valid argument could not take one from true premises to a false conclusion. Thus, were one to generate a prediction about something observable by way of a valid argument with a bit of theory as a premise, one could know that, were those observations not to obtain, . . . well the premises could not all be true. To the extent that one could judge that the other premises were true, one could learn of the falsity of the theory.

If good arguments are to generate knowledge, as the Buddhist philosophers hold, then a good argument must start with premises known to be true. Further, the truth of the premises must turn on non-accidental relations between the properties mentioned in the premises. (This requirement does find parallels in Western philosophy of science—although there it is associated with the idea of a good explanation rather than of a valid argument. Compare the Western philosophical idea that causal understanding turns on the properties to which one appeals actually being causally relevant, and not just correlated (the drop in mercury levels of a local barometer is not itself a causal explanation of the storm). In effect, the substantive relationship between properties—commonly a causal relationship—is of concern in Buddhist logic and Western philosophy of science, but this concern is reflected in different ways of partitioning the issues. For the Buddhist logician, it is required for good—knowledge productive—inference. For the philosopher of science, it is required for explanatory accounts, and not for logical validity (and, understandings of causation also exhibit some differences, see below).

Consider the following inference recognized by Western logicians as of the form *Modus Ponens:*

> If there is smoke on yonder mountain, then there is fire on the mountain
>
> There is smoke on yonder mountain
>
> Therefore, there is fire on yonder mountain

While Buddhist logicians would agree that the presence of smoke could be a reason for thinking that there was fire on the

[1]For background on Buddhist philosophy and epistemological traditions, together with some comparisons with Western Analytic Philosophy see D'Amato, M., J. L. Garfield and T. Tillemans, Eds (2009). Pointing at the Moon: Buddhism, Logic, Analytic Philosophy. New York, Oxford University Press, Garfield (2011). Western Idealism and its Critics. Samath, Varanasi, Central University of Tibetan Studies, Westerhoff (2018). The Golden Age of Indian Buddhist Philosophy. Oxford, Oxford University Press. Also of use might be the Stanford Online Encyclopedia of Philosophy on Dharmakī, https://plato.stanford.edu/entries/dharmakiirti/#LogLog.

mountain, they would insist that more than the form or structure of the statement seen here is important. According to Buddhist logicians, a good argument, one sufficient to produce valid cognition, must satisfy three conditions. The first two lines of the opening stanza after the verses of homage and pledge of composition in Dharmakirti's *Pramanavarttika* are:

> The inferences that fulfill the [conditions of]
> being true of the subject and the pervasions are three in types[2]

First, the reason must be true—there must be smoke on the indicated mountain. Second, the proponent of the argument must specify an example, different from the case under discussion, where fire is associated with smoke, e.g., when there is smoke in the kitchen, there is necessarily fire somewhere around. An acceptable example illustrates a commitment to *the necessary connection* between reason and conclusion: smoke is necessarily produced from a fire (although fire may not necessarily entail smoke). Third, the reason must be restricted. The reason (the smoke) is necessarily absent in any case where what is to be proven (the fire) is also absent. The second and third conditions introduce what is called the *pervasion*, and they strengthen the relationship between smoke and fire so that knowledge of smoke on yonder mountain yields knowledge of fire. The remaining two lines of that same opening stanza in Dharmakirti's *Pramanavarttika* are:

> Because they are bound in a relation of necessary pervasion [both of absence and presence].
> All the remaining inferences are unsound.[3]

Pervasion looks to be an important place where Buddhist packaging of issues is different and yet the underlying issues may be recognized as having parallels in Western philosophy. Pervasion has to do with ideas about kinds and causes—fire causes smoke, or more fully: smoke is the kind of phenomena caused by fire, and fire is the kind of thing that causes smoke. Insofar as it is connected with ideas about causation, it also connects with two issues in scientific epistemology on which we find parallels and differences.

The first concerns knowledge of the causal connection between the relevant properties, how one can make generalizations responsive to observed patterns of covariation. In both traditions, one encounters issues about how one can be confident of the generalizability of the patterns observed. Here, Western epistemologists think of something on the order of induction. But the Buddhist tradition does not recognize inductive inference as Western philosophers and scientists do! Thus, there is both a similarity and a difference to be negotiated.

The second issue turns on the idea that there exists something on the order of a necessary truth that is rooted in the conventional, empirically inspired, concepts of *smoke* and *fire*—one might say that it is an aspect of our concepts that smoke is just the sort of particulate atmospheric emanation caused by fire, and that fire is the sort of process that, when not perfectly efficient, produces smoke. Buddhist thinking here resembles a view put forward by some Western philosophers: in the context of empirical inquiry, some concepts arise in such a way that causal connections are built into the concepts themselves (think of the conceptual interdependence of *mass* and *force* in Newtonian mechanics). The parallel here is that both traditions have reason to reflect on claims that are both empirically rooted and conceptual at the same time. But, again, to avoid an overly simple understanding of this parallel requires carefully reconstructing ideas within each tradition, rather than grabbing onto simple equivalences.

RESULTING CHALLENGES OF TRANSLATION

In the face of differing yet overlapping concerns and differing but related understanding of problems approached, the solutions hit upon within the Western and Buddhist traditions have generated different conceptualization of the elements of epistemology and logic. This makes for real challenges in mutual intelligibility: a different system of knowledge (Western science) that has developed in the context of a different evolving logic and epistemology is introduced to an audience who already has sophisticated accounts of knowledge and reasoning which evolved in yet another context with differing conceptualization and formulations. In coming to know any rich and mature system of thought, the student must manage to so reconstruct the system that they can have a sense for why one would make the connections made—in some sense mirroring or approximating an understanding "from the inside".[4] They must appreciate how the thinker(s) formulate their problems, enabling them to recognize constraints and reason toward answers. As instructors in ETSI, we faced a pedagogical problem: how do we help students who already have sophisticated accounts of knowledge and reasoning come to understand a system of knowledge (Western science) that has developed in the context of a different logic and epistemology? Doing this well not only required us to get some interpretive purchase on the other's ways of seeing the problem, but it also required negotiating some very difficult issues of translation.

To provide a context for understanding the challenges faced, it is worth pausing to characterize the structure of the first 6 years of the ETSI program—that in which instruction was carried out by practitioners of Western science and philosophy of science

[2]Dharmakirti, *Pramanavirttika*, chapter 1, Toh. 4210 Tengyur, tshad-ma, ce, 94b3.
[3]Ibid., 94b4.

[4]For the author's philosophical understanding of interpretive understanding, see Henderson (1993). Interpretation and explanation in the human sciences. Albany, State University of New York Press, Risjord (2000). Woodcutters and witchcraft: rationality and interpretive change in the social sciences. Albany, State University of New York Press, Henderson (2010). "Explanation and Rationality Naturalized." Philosophy of the Social Sciences 40(1): 30–58.

cooperatively teaming with translators. The translators were commonly monastics who themselves had recently developed Western scientific literacy. ETSI's target audience is Tibetan monastics, comprised of both monks and nuns. The monastics were engaged in the later stages of their monastic education—roughly equivalent to graduate studies within a Western education. The program consisted of six consecutive years in which about 1 month of the monastic calendar was devoted to the ETSI summer intensive program studying physics, biology, and neuroscience (each in about 1 week of courses each year). Most instructors were by college and university faculties visiting from the West. (Apart from the summer program, the monasteries have begun year-long classes in the respective scientific disciplines with their local instructors composed of both monastic graduates and lay graduated from modern universities.) Because traditional monastic education would have had sustained engagement with philosophical reflection on matters epistemological, it was thought that the philosophy of science would provide an approachable introduction into a science education. This itself made for interesting challenges, as one needed to provide potted examples of scientific work and results in order to illustrate the epistemological issues that was the course focus. The summer intensive philosophy of science course itself is about 1 week in length at the beginning of the initial year. It met in two sessions each morning, for about 3 h of structured presentation. This was followed each afternoon with sessions in which the monastics would pose questions, resulting in commonly lively discussion. Particularly in these afternoon sessions, instructors and translators were able to get a reasonable purchase on how well the instruction was coming across. It should also be noted that in a recent webinar with some 60 monastics who had completed the course of study, graduates proved able to trace a number of differences and continuities between the philosophy of science and Buddhist philosophy. They were sensitive to the differences in understandings of inferential knowledge and of relevant presumptions of the respective traditions. (The graduates participating in these sessions did the same for the other disciplines that are the focus of ETSI as well.)

Instructors confronted an unusual challenge from the outset: the instruction must take place in a language foreign to many of the monastics—English—and be brought home to the monastics via translation into Tibetan. With no prior precedent for teaching modern science to a Tibetan audience in any form, let alone in a sustained and comprehensive manner as ETSI, that also meant having to improvise Tibetan equivalents for the technical terms and foreign concepts being encountered as the instruction progresses. This pedagogical challenge increased when it came to the philosophy of science. The monastics who enrolled for the program would already have had no less than 10 and as many as 15 years of rigorous training and engagement in philosophy and metaphysics through the medium of their own sophisticated and well-developed system of logic and epistemology. Unless great care is taken in translation, the sophisticated training of the monastics could *add* to the challenges instead of mitigating them. (Happily, going forward instruction will be carried on by a devoted staff at the monasteries who themselves have lived the challenges in a way that equips them to as the interlocutors in this exchange of concepts and traditions).

Translation must be undertaken so as not to tempt the students with a false understanding of the claims advanced in the course. Wanton translation would either assimilate the scientific epistemology and logic in a way that would reassuringly erase differences, or (ultimately) would treat each tradition as doing the same thing—engaged in straightforwardly the same epistemic projects and problems—but each would see the other as doing so in a ham-fisted way, unresponsive to obvious problems. Given the situation, those presenting the material have a special responsibility in facilitating the delivery and enhancing mutual understanding, not contributing to the confusion. Much of this burden fell upon those members of the presenting team who were most qualified to be responsive: *the translators* found themselves facing a delicate and demanding task. Happily, the translators both happen to be adequately trained in the traditional Buddhist system of education and had English language skills for comprehension and conveyance of the Western knowledge system. With ready access to the Western professors, they could pursue clarification and perspectives, and did so both in and out of class. Notably, they did not come to this role as translator in class without the benefit of much preparation. They were attentive to the differences between the traditions evidenced in pre-course study of the subject matter and their pre-lesson preparations—additionally, most translators had been responsible for the translation of textbooks, lesson slides, and notes. As a result, these translators were alive to the subtle and nuanced differences in the understandings and approaches of the two traditions. So much so that they were alive to this delicate challenge: readily *borrowing technical terms from Buddhist sources in conveying concepts and notions from Western traditions was recognized to be off-limits*—as the Buddhist technical terms were recognized as potentially engendering unnecessary mutual puzzlement and confusion instead of aiding in comprehension and intelligibility.

So, how did the translators approach their responsibility? To the extent required and possible, they strove for new terms for the novel concepts that the monks needed to grasp. Presenting the concepts in these new terms highlighted the novelty of the concepts being conveyed and the essential distance in their implications from those of the already familiar concepts or notions in Buddhist system. For example, the translations convey "induction" and "deduction" in totally new expressions, even though it meant coming up with a phrase for each instead of a convenient single term. The translation team has yet to settle on convenient single-term equivalents that would be both palatable to the students and sufficiently representative of the source terms. Though far from a satisfactory rendition, the current expressions in Tibetan capture some common features of those reasonings as practiced in Western tradition. Admittedly, even this characterization covers only a partial truth about the inferences in the Western tradition and thus warrants further improvement, which the translators are always open to explore. However, it is far safer and more convenient way of handling them for the time being. It minimizes the risk of confusion and puzzlement arising out of conveniently simple, but distorting, equivalences.

Similarly, while there are ideas in the Western traditions of scientific practice and philosophy of science that bear cross-cutting and partial parallels to the notion of pervasion within Buddhist epistemology, our translators have shied away from using the Buddhist term for pervasion as a translation for *any* term in the Western tradition. This is again because, aside from the superficial similarity, there is a marked difference in the actual form and significance of the respective traditions.

Another example of carefully negotiating the choice of words in translation is for the terms "realism" and "antirealism." Given that the whole of Buddhist thought is systematically geared towards establishing the primacy of mind over matter, subjective as opposed to objective, there is no dearth of established terms to choose from and made use of. That includes compact technical terms used for connoting the "absence of objective world external to consciousness" as advocated by the Mind-only school, or the more popularly acknowledged terms connoting the "absence of inherently, truly, intrinsically existent phenomena," as proposed by the Middle-way school in Buddhism. That would have been an easy choice and still capture the intended partial meaning in the Western tradition, but at the risk of creating confusion and naive associations on the part of the students. Instead, the translators created a hybrid term that leaves the students at a loss to make ready associations, and instead makes them wonder about the actual intended meaning behind the novel terms, hopefully ultimately leading to a better understanding of the original source. Unlike the sciences, which are new and unfamiliar to the monastics, translating for the philosophy of science keeps one on the alert all the time and always making sure one thinks twice before ever deciding to use an already loaded term.

Europeans have often imagined situations of mutual unintelligibility and wonder how communication would be possible. Our experience with teaching the philosophy of science to Tibetan monastics shows that *the really difficult problems arise not from total unintelligibility, but from partial intelligibility*. These problems can be surmounted, but they require patient attention to both tiny nuances of meaning and grand differences of perspective. ETSI has inaugurated a significant project with a long horizon, and we can only hope that future generations of monastics and European-trained philosophers keep the conversation alive.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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The Path of Science in Future Tibetan Buddhist Education

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The Emory-Tibet Science Initiative (ETSI) allowed western science teachers to work with monastically educated Buddhist monks to further their science education. The challenges included teaching through translators, using best practices for teaching within a religious community, and thinking about how to integrate what we learned from teaching in this context to our classrooms back home. In this article, we, a diverse group of western college-level educators and scientists, share our personal experiences and thoughts about teaching in this unique context in several themes. These themes are the challenges of translation and the development of new Tibetan science dictionary, the importance of hands-on learning opportunities as an example of using best teaching practices, using technology and online resources to connect our communities through both space and time, and the imperative of future plans to continue these important cross-cultural efforts.

Keywords: emory-tibet science initiative, science education, monastic education, student engagement, cross-cultural education, lecture and lab practicals, #instaMETSA, foldscope

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INTRODUCTION

A great appeal of teaching biology in the Emory-Tibet Science Initiative (ETSI) program is the opportunity to meet new colleagues and forge a scientific and cultural understanding among biology teachers from across the United States, the Tibetan Buddhist Geshe Professors from ETSI, and the monastically educated monks starting to learn Neuroscience on their path to become science Geshes at Sera, Gaden, and Drepung Monasteries. During our experiences from 2015 to 2019 with classes in Years 1–6, we confronted the challenges of language translation in education, determined good practices for teaching within a religious community where some scientific views may be controversial, and integrated our learning from the monks into our science instruction practices at home. In this manuscript we share experiences and classroom practices that illustrate the challenges and rewards of teaching in, what was for us, a new and exciting setting. We also address a current challenge: maintaining and expanding science education at the Monasteries in the coming years despite the COVID-19 pandemic, the great distances between us, and the language barriers.

We share our personal narratives and thoughts, and connect these narratives to several important themes: language translation and the development of a new Tibetan science dictionary, the best practices in education, including hands-on activities and debate, and the dual use of technology to keep our communities connected across great distances and time. We also discuss some of the lessons we learned that have influenced our classrooms at home.

THEME #1: THE CHALLENGES OF TRANSLATION AND THE USE OF A NEW TIBETAN DICTIONARY: SENTIENCE AND THE MEANING OF LIFE

When Denise and her colleague Erica first arrived at Gaden in 2015 to teach Introductory Biology to the first-year class, they shared a naive understanding of the challenges that they would experience when teaching through translators. They knew the process would require them to think carefully and speak precisely. They also knew that they would need to be sensitive to differences in the way western scientists and the monks view the world. But beyond those elementary recognitions, they were unprepared.

As an example of the challenge of translation, Denise and Erica were not aware that the science monks had two different words for "living." They have a traditional Tibetan Buddhist word that restricts the notion of life to sentient beings. And they have a newer word that encompasses the western scientific definition of life. Western scientists consider all plants, animals, fungi, and bacteria to be living, but do not believe them to be sentient. During Denise's first year of teaching, the class discussed and debated the idea that plants are living organisms. At first, these discussions were quite frustrating! For example, during a morning class the monks would happily conclude that plants are living, but within another session, sometimes only 1 h later, the monks would get upset at the suggestion that plants were living, and would argue strenuously that the science teachers were wrong.

What was happening? Denise and her fellow teacher were befuddled for days until they realized that it was an issue of translation. If the translator used the word indicating the western scientific view of life, all happily accepted that plants are living. If the translator used the word indicating the traditional Buddhist view of life as sentient, all the monks disagreed that plants are living. Fortunately, there were several translators, and during a teatime discussion the source of the confusion was uncovered. This new understanding provided an engaging opportunity to further explore both scientific and Tibetan Buddhist thought on the definition of life.

To further this discussion and exploration, during discussions in our morning classes the monks were provided with examples of plants engaging in sentient-like behaviors. For example, parasitic plants can recognize and select which plants to parasitize; plants can communicate with other plants, such as to signal an injury, as well as to other species such as insects and bacteria; and plants can "see" the world by interpreting different wavelengths of light. Microscopes were used in the afternoon labs to view plant stomata–structures used by plants to regulate the exchange of CO_2 and O_2 in and out of the plant–and discuss how plants "breathe" by opening and closing their stomata in response to changes in their environments. Certain plants synthesize organic compounds that alter the mind and behavior of sentient beings. Plants move more slowly, and act more quietly than most sentient beings. These differences mask the sentient-like behaviors of plants, and elicit the question, what are the biological mechanisms that confer sentient-like behaviors in organisms lacking a nervous system? Questions such as these provide great opportunities for debate and discussion in the classroom and encourage practices that lead to greater student engagement. As others have concluded (Pascarella and Terenzini, 1991; Shulman, 2002; Lei et al., 2018), the greater the classroom engagement of students, the deeper their learning.

THEME #2: BEST PRACTICES IN SCIENCE EDUCATION: THE IMPORTANCE OF HANDS-ON EXPERIENCE TO FURTHER SCIENTIFIC UNDERSTANDING

The great difference in the time scale of a human life span versus the evolution of the extant species obscures the origins and relationships of fundamental features among living organisms. So do great differences in scales of size, such as bacteria versus elephants. Two years after the events told in Theme #1, in 2016 during a third-year class in Biology at Drepung Monastery, Ernest and Tom revisited the discussion, "What Is Living?" The morning lectures revealed differences in basic concepts among the science monks and the western biology teachers. The afternoon labs provided hands-on experiences to further engage these discussions. Students were directed to collect samples from standing muddy water. Ernest and Tom demonstrated preparing slides with the samples, finding organic matter in the field of view, and focusing the microscope.

The world of micro-organisms in pond water is a fascinating discovery for anyone who gazes upon a sample through the microscope. The structural beauty of micro-organisms only visible in the microscope, the mesmerizing motion, the seemingly intelligent behavior of apparently rapidly moving beings avoiding each other while seeking food. One monk, watching this spectacle through the microscope, described to his fellow lab mates the intricate dance before him (**Figure 1A**). As if watching a performance, awestruck by a particularly nifty maneuver, the monk was overcome by an epiphany. He rose smiling from the microscope eye pieces, and proudly announced his discovery to all in the lab, "it's sentient!"

The concept of a fundamental distinction between sentient and non-sentient beings had not crossed our minds while teaching biology in America. Most biology instructors think and teach only in terms of living versus non-living. Western biologists draw distinctions between free-living cells and viruses because the latter are dependent on cells that encode the metabolic genes necessary for viral replication. The sharpness of this boundary begins to fade in discussion with the science monks. They ask, is not self-replication, in any form, dependent on other self-replicating life forms?

While teaching biology at Drepung Ernest and Tom first considered the notion of a fundamental distinction between sentient versus non-sentient beings. This is likely because American culture is not heavily invested in answers to the questions, "Is this a sentient being?" or, "Does this being have the ability to perceive or feel emotion?" The implications for most Americans are rather inconsequential, but for the monks of

FIGURE 1 | Morning class and afternoon labs, Drepung Monastery. **(A)** Science monks running the show during the afternoon lab microscope demonstration. **(B)** Using Foldscopes and posting images.

Dreprung, it meant that sentient microscopic creatures are regulated by a special set of rules. In Buddhism, all sentient beings possess Buddha-nature and have human connections through cycles of rebirth. Therefore, Buddhist are not permitted to harm, kill, or eat sentient beings. These commandments have major implications for the afterlife. This perspective not only mandated a vegetarian diet but also had a profound impact on our lesson plans, experiments, and discussions about the organisms of the microscopic world.

Finding compelling laboratory endeavors that complement classroom discussion is a never-ending challenge. Sensitive to the restrictions of experimenting with sentient life, the biology teachers in 2019 Year 5 (Immunology and Disease) proposed that the science monks assess the fungal infection in their neighboring orchard. Of 80 monks in the classroom, only one showed initial interest. The monks asked, "Why study plants if they are not sentient beings—what relevant knowledge and skills would we gain from this exercise?" The counter argument from the teachers was that plants were living, in the biological sense, and because they were not sentient, and we would only be collecting infected leaves, we could investigate plants and practice scientific approach without harm. Furthermore, we could learn critical information about the fungal infections threatening the viability of the orchard, particularly since the monks liked to eat the butter fruit (avocado) and mango harvest. This convinced a few more of the leaders among the science monks, and within a minute of further discussion we had 23 volunteers to sample the entire orchard. That afternoon the science monks took charge and assigned data collection responsibilities by row, gathered the separate data sheets, and without error compiled all data onto a master sheet (**Figures 2A–C**).

We basic research scientists could learn from the orchard demonstration of self-organized teamwork, precision, and accuracy. Such experiences in the monasteries stimulated us to reflect on our practice of teaching students in science classrooms in American universities. Through our collective discussions over the years, we have all thought more carefully about our definitions of life and recognize both the similarities and the differences between our ways of viewing the world. The need to use language carefully is common to both settings. More importantly, we were able to reflect on the students' engagement with the material. The debates we had in our monastic classrooms were lively and engaging, and we all left the classroom feeling intellectually stimulated.

Chickering and Gamson (1989) stressed the importance of engagement in good educational practice in their influential essay, "The Seven Principles for Good Practice in Undergraduate Education." In particular, they stressed that good practice encourages contact between students and faculty, cooperation with other students, and active learning. The practice of debating issues of importance to students satisfies these three points. This is uncommon in our American classrooms because too often students do not see connections between the material under discussion and their personal lives. Through our ETSI experiences, we have learned to better recognize engaging links between classroom topics and real life for our students.

THEME #3: TECHNOLOGY CONNECTS OUR COMMUNITIES THROUGH DISTANCE AND TIME

One of the appealing aspects of teaching in ETSI is the freedom individual instructors had to convey information to an extensive range of students in age, education, and experience. Instructors gathered in the monasteries from a wide variety of institutions across the United States. We learned new technologies and approaches to teaching from each other and the science Geshes (examples follow). The new outlook helped us embrace diversity at our home institutions and transform our teaching.

Microcosmos: As part of the Year three class in Biology (Genes and Cells) in 2018 at Drepung, Pamela and Pantelis brought origami "FoldScope" microscopes for each monk. These inexpensive microscopes ($3.50 each) are assembled by students from a kit of cardboard components and a lens; and have a magnification of ×140 and a resolution of 2 μm.

During an afternoon activity session each monk constructed his own microscope according to a FoldScope website (www.foldscope.com) instructional video describing the process of joining cardboard, tape, and lens. Despite the challenges of translating an English video

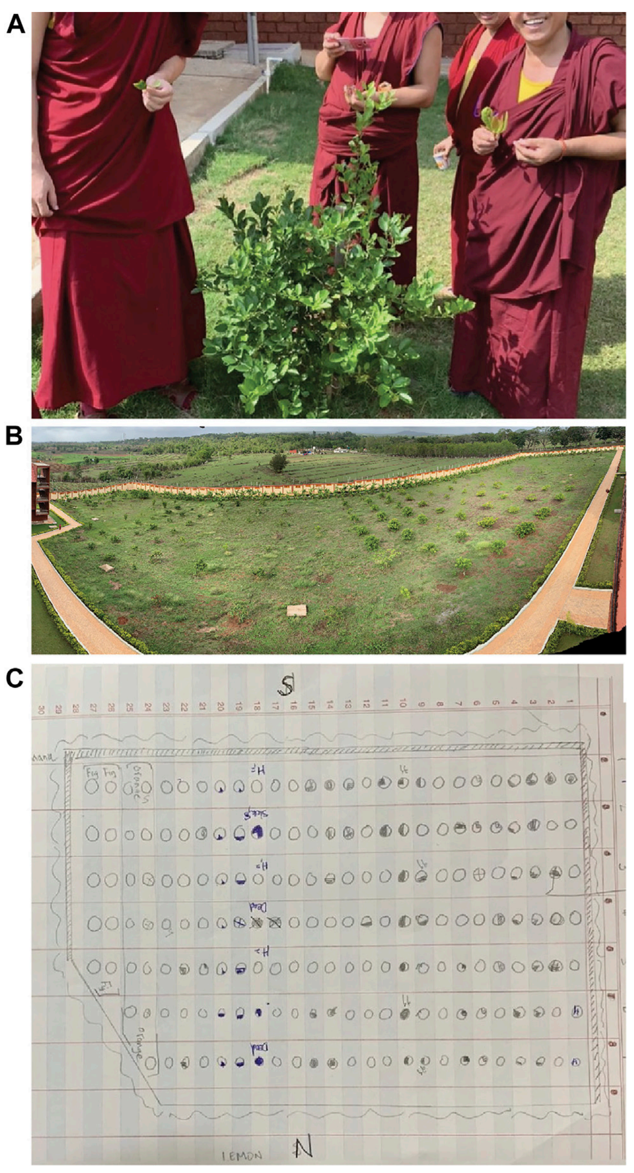

FIGURE 2 | Fungal infections in the orchard (2019 Year 5, Drepung Monastery). **(A)** Science monks collecting infected leaves. **(B)** Wide-angle photo of the infected orchard. **(C)** Final data sheet of the distribution and extent of infection in each living (circle) and dead tree (X or entirely filled in circle) compiled from data collected by 23 science monks individually sampling one or two rows in the orchard.

into Tibetan, all 70 science monks in the class assembled a FoldScope (**Figure 1B**). The monks were then dispersed, challenged to find biological samples in pools of water in gutters, drainages, or surrounding fields. They mounted these samples on slides, and documented their observations in drawings, as well as photos and videos using a smartphone attached to the FoldScope with a magnet. Several monks posted distinctive photos and videos of microscopic creatures swimming in pond water. Of the many observed micro-organisms, the multi-cellular invertebrate rotifers (0.1–0.5 mm long) were the most easily identified. While swimming they looked streamlined, like tiny nematodes. But when they found food, typically protozoa and algae, the rotifers transformed, as if magically. They attached to a substrate by their tail spurs, and hidden trochal discs emerged and spun rapidly to channel food through their mouth and into their stomach.

These observations led to an impromptu lecture on rotifers using information and anatomical diagrams gleaned from the internet; and reinforced concepts about organ systems, such as their "pseudo coelomic" digestive system, which had been discussed earlier in the morning class. The monks were inspired to use their FoldScopes to observe slides prepared by themselves or from biological supply companies available in the lab. They posted photos from their smart phone, pad, or laptop computers (**Figure 1B**) to the Microcosmos website (microcosmos.foldscope.com/), alongside posts from users around the world sharing FoldScope images, videos, and blogs. Several monks were motivated to make videos translating the FoldScope instructions from English into Tibetan, and another monk made a version in Nepali.

Sufficient unassembled FoldScopes remained at the monastery for each of the nuns taking Biology in 2019 to assemble their own by the guidance of the Tibetan-translated folding assembly video. Future observations and discoveries from the science monks and nuns as they independently explore their environments extend the influence of the ETSI experience.

Effective science pedagogy includes student engagement as well as opportunities for students to use the tools of scientists. Edgerton (2001) stresses that for students to truly understand a discipline, they must engage in tasks and activities that specialists perform within that expertise. By introducing the science monks and nuns to microorganisms, they now have a deeper knowledge of the biological world, the practice of science, and the importance of technology in influencing our understanding of the world.

#instaMETSA: #instaMETSA is a communication platform that focuses on telling science stories in pictures on Instagram. FoldScopes coupled with smartphones or iPads provide an excellent opportunity for the science monks to communicate with other scientists from different parts of the world. The activities include assembly, creative acquisition of samples, and sharing stories of discovery, experimentation, method, mechanism—any creative process that can be described in pictures or videos, and a few words.

Communication is an essential aspect of scientific discovery. Scientists tell stories of their findings—tales woven of facts rather than fiction—in words and pictures. Telling a good story takes practice, feedback, and revision. The challenge in teaching is to stimulate students to discover their own interests and build their own networks of scientists and projects. As such, #instaMETSA is a useful venue for young scientists to describe their discoveries in 10 panels within a structure of Title, Abstract, and Figures (still or video). Instagram features include comments and messaging functions, allowing public and private discussion. Revised posts can replace earlier drafts. This is much like the process of publishing scientific manuscripts and grants, with reliance on friends, colleagues, and people in the research community who can improve the research and the true stories that we share. Through #instaMETSA, trainees and mentors share their discoveries, discussions, and revisions in small private groups, across the three ETSI science monasteries, or around the world.

Video shorts: The Emory-Tibet Science Initiative (ETSI) program explores the interface between science and philosophy in Physics, Biology, Neuroscience, and the Philosophy of Science. Additionally, a course on scientific method and English language for the younger monks in residence within the greater Drepung Monastery was taught by Jordan, Tovah, and Galen in 2016 and 2019.

While living at Drepung and teaching at the Sakya Monastic School in 2019, Galen learned that although the young monks may live a vastly different lifestyle than kids their age in the United States, they share the same fascination for social media. The young monks enjoy occasional access to smart phones and the internet, and a few even have Facebook accounts, but never had they starred in their own video production.

Galen was initially enrolled to help Professor Carolina Compos teach young monks basic English. The two of them developed an imaginative project that would simultaneously use Galen's expertise in video production and improve the monks' English. Galen filmed a skit starring several of the young monks. The initial concerns were the language barrier and limited acting experience. However, five young monks had great excitement about the project, and had blocked out a skit and roles before meeting with Galen. To Galen's astonishment, they proposed to perform a short story from one of their books that mirrors the "Who's on First" skit by comedians Abbott and Costello. The young monks' version featured three friends, "You, Me, and Minddle." When You goes missing, serious confusion erupts as his friends seek help from the police and other adults. Denied help and threatened with punishment by the frustrated adults, Me and Minddle give up the search, only to find You at home feasting alone on their lunch snacks.

Carolina and Galen helped the young monks write their scripts in English. The actor-monks surprised everyone by memorizing their lines, making storyboards to establish scenes and locations, and producing advertising posters with their names and roles. After 1 day of rehearsal, 3 days filming, and 2 days editing, they were ready to show their masterpiece to the young monks and professors on the final night of class. From the hilarious acting to funny bloopers, the premiere was a blast for everyone. After the first showing, the young monks demanded repeated encores so they could see themselves and their friends on the big screen. Galen is delighted to have helped them experience writing, acting, and producing their own movie short. It is a pedologic technique Galen learned from his own school projects. In turn, the young monks' commitment and enthusiasm, despite language barriers and a quirky, demanding director, inspires Galen to this day.

LOOKING TO THE FUTURE AND LESSONS LEARNED: HOW HAVE OUR EXPERIENCES CHANGED OUR CLASSROOMS AT HOME?

Graduation day celebrates collective accomplishments at the conclusion of each section of the summer science classes in Physics, Biology, Neuroscience, and the Philosophy of Science. It is a time to take heart in the amazing advancements in science education accomplished by the ETSI project over the first 13 years of the undertaking, and to contemplate plans for expanding science education and contributions by the science monks at Sera, Gaden, and Drepung. Areas of expertise might first include the objective needs for clean water, food, and health care, as the monks build towards scientific expertise in Neuroscience, Mindfulness, and Compassion. While it takes decades to build the laboratory facilities and technical expertise to contribute to global science advancement, more rapid contributions to cutting-edge science might be achieved by building think tanks in select fields and developing ideas with scientists around the world. The science monks and nuns can hone their scientific thinking by critically evaluating current literature, writing white papers in traditional journals, and producing visual content in new online platforms. Future Tibetan Buddhist scientists could help lead the world in the most immediate areas of need and interest among the science monks, nuns, and young trainees.

Teaching in unique classroom and laboratory settings in the monasteries transformed our approach to classroom and student interactions at home. Beach et al. (2016) conducted a large-scale study of the field of faculty development in higher education. Three conclusions of this study relevant to our experiences are the importance of engaging in student-centered teaching, integration of technology into classroom and learning environments, and multiculturalism and diversity.

Denise and Erica's experience of struggling with the challenges of teaching through translators and debating about the scientific meaning of the term "life" versus the Buddhist meaning of the term underscores several important issues. These issues include the increasing challenges in teacher-student communication as classes become more diverse. For example, terms that have specific meanings within science may have different meanings outside of science. As faculty, we typically have different backgrounds and language usage than our students. Our experiences teaching in the monastery reminded us that building a shared vocabulary with our students enhances learning and emphasized the value of a student-centered classroom where students are actively engaged in learning. By contrast, teacher-centered classrooms create a one-way dialogue with the instructor telling the students how the discipline works. By creating a classroom environment where the monks felt engaged and welcome to share their point of view, we were able to overcome a problem of translation.

One important goal of the use of technology in the classroom is creating opportunities for students to engage in learning communities. The use of #instaMETSA and the Foldscopes allows students from anywhere in the world to share their science. Scholarly video shorts can be shared with other students around the world. These activities increase student engagement within the discipline and provide students with greater ownership of their learning. Seeing the effectiveness of these practices has encouraged us to use similar tools in our home classrooms and modify some existing assignments, such as traditional lab reports, into video productions that engage the students more fully.

The Association of Public and Land-grant Universities (2019) surveyed University presidents, provosts, and student affairs professionals about the greatest challenges facing higher education. The survey identified student mental health as one of the top challenges. Student anxiety is a serious classroom issue that hinders learning and can cause students to either leave their desired major (this is a particular problem in STEAM fields) or leave college entirely. One aspect of student anxiety is a fear of academic failure. Recent studies (for example, Hjeltnes et al., 2015) have looked at the potential for mindfulness techniques to help students reduce their anxiety with a goal of "moving from fear to curiosity" in academic learning. As guests of the monastic community, we were all provided the opportunity to learn to meditate and engage in other mindfulness activities and some of us now use these techniques in our classrooms.

We witnessed the curiosity monks had for learning science. A notable difference between our classes at the monasteries and our classes at home was the joy and curiosity monks had for science. Without the fear of tests, grades, and "wrong" answers, the monks could focus on their own curiosity. Eric Mazur, the Harvard physicist turned science education guru, has spoken of assessment as the silent killer of learning. This idea becomes more salient after the teaching experience at the monastery. In the United States we created an educational system that rewards focusing our students on grades. An ambitious goal, very much a work in progress, is to transform our classrooms from rewarding points to encouraging learning.

The experiences of our ETSI classrooms were profound and have influenced our teaching by being more mindful of the importance of language and diversity, reinforcing the value of student-centered classrooms and student engagement, and using technology to create authentic learning communities for our students. Mindfulness techniques and changing our classrooms to reduce student anxiety and fear-of-failure are also important results of this experience.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

TW, JJ, and DW collectively wrote the first draft of the manuscript. Contributed to conception and design of the study. DW, JJ, TW, PB, PT, ER, and GW wrote sections of the manuscript. All authors contributed to conception and design of the study.

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Tibetan Monastics Reflect on Science and Buddhism: (I) The Basic Human Nature and (II) Subatomic Particles

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One of the goals of the historic Emory-Tibet Science Initiative (ETSI) is to catalyze cross-cultural thinking among scientists and Buddhists. Over a decade into the project to elicit such thinking the project sponsored an essay competition among the monastics. Here we feature two of the winners reflecting on different aspects of western sciences and Buddhism, physics and Buddhism respectively, demonstrating how modern science is integrating with the monastics' traditional training and culture. A key aspect of ETSI is also translation, and these essays, in that spirit were translated from Tibetan to English by one of the project translators.

Keywords: human nature, compassion, buddhist philosophy, modern sciences, subatomic particles, atoms, elementary particles, quarks

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INTRODUCTION

Since its inception in 2006, the Emory-Tibet Science Initiative (ETSI) has introduced modern sciences to thousands of Tibetan monastics through well planned programs. Now moving into its sustainability phase, ETSI focuses on training indigenous science teachers and researchers through pedagogy and research workshops. To not only diversify and enrich scientific literatures in the Tibetan language, but also to catalyze cross-cultural thinking, the program has recently sponsored an essay competition among its participants, and two of the winning essays were selected and translated into English by one of the ETSI translators. While the first essay compares and contrast Buddhist views with western understandings on the basic human nature, the second essay reflects on subatomic particles from Buddhist accounts and scientific discoveries.

BASIC HUMAN NATURE

Introduction

The question of basic human nature has been the most important topic of debate and investigation for many centuries among philosophers, founders of religions, and scientists, because the goal of all people is to seek happiness and avoid suffering. The methods to attain this ultimate goal exclusively depend on how humans recognize their own nature. His Holiness the Dalai Lama said, "As a matter of observation, how people treat their fellow human beings, and indeed the world around them, largely depends on how they perceive themselves. We all have many different ways of seeing "who we are," and these different views influence our behavior" (Lama, 2016).

Since the start of the Age of Enlightenment in the west, and specifically the formulation of Darwin's Theory of Evolution, one of the popular views considered basic human nature as selfish and outright competitive (Jinpa, 2015). However, current life sciences and primatology research show that basic human nature is compassionate. Moreover, His Holiness has said "it is especially happy and encouraging because basic human nature is compassionate" (Lama, 1998). Therefore, in this essay I will explore how Buddhism, western religions, philosophy, and science identify basic human nature, and will investigate how Buddhists examine western views. In this context, basic human nature means the innate character of a human being.

Western Views and Buddhist Thoughts on These Views

Christian View

According to Christianity, Adam and Eve were created by God in the image of God (Genesis, 1980) and given the wisdom to distinguish good from bad, however, they ate the forbidden apples and in doing so stained their pure nature. "Even today, there are Christians and Jews who believe that human nature is bad and to escape it one needs to become a follower of God or Christianity" (Wallace, 2009).

Well-known Tibetan religious philosopher Tsongkhapa (1357–1419) said, "The world of sentient beings is due to the karma and afflictions accumulated by the mind. Different physical worlds arise due to the specific karma accumulated by the mind of those sentient beings" (Tsongkhapa, 2015). Therefore, Buddhists do not accept the concept of God or a Creator but believe that all sentient beings arise in a variety of forms due to their karma accumulated over many lives. One unique notion of Buddhist karmic view is that one will not undergo consequences of an unaccumulated karma, and an accumulated karma will not be wasted (Samdhong, 2020). Therefore, if all human beings became sinful because of Adam's action, it would contradict the Buddhist view of karma that posits humans face the karmic result of their own action.

Western Philosophical View

Innate knowledge has been a main point of argument between rationalists and empiricists (Messerly, 2014). Rationalists claim some concepts are innate while empiricists believe all concepts depend on actual experiences. As a rationalist, Descartes believed that true knowledge of examining an object arises through mental perception, where senses deceive and are deceptive. Consequently, he claimed to doubt all beliefs, as all beliefs are acquired from the senses (Monette, 2018). Prof. Jay Garfield mentions Descartes' view in *Western Idealism and Its Critics* where he says, "human nature is capable of thinking" (Garfield, 1998).

Empiricists like Aristotle and John Locke believed that human nature is formed through one's environment and experience, and that the mind at birth is like a *tabula rasa*, neither good nor bad, and incapable of perceptual judgement. John Locke attacked Descartes' idea by stating that if humans have innate nature, all should have the same innate nature (Pinker, 2016).

The western philosophical view accepts the concept of innate nature and is more closely aligned with Buddhism. In *Commentary on Valid Cognition*, 6th century Indian Buddhist philosopher *Dharmakirt*i said "a non-consciousness cannot be the substantial cause of consciousness" (Dharmakirti, 2004). As this indicates, the consciousness of a newborn should arise from a previous consciousness as its substantial cause. As a dualist, Plato believed in the separate existence of material body and immaterial mind, the realizer being the *self*, and the *self* existing before birth and after death (Messerly, 2014).

Rationalists postulate that knowledge must be composed of conceptual thought, whereas empiricists assert that every knowledge arises from sensorial perception. From Buddhist epistemology, both of these perspectives amount to nihilism. In Buddhism, an object of knowledge is necessarily either particulars such as a yellow cup or universals such as a cup (Encyclopedia, 2021). Therefore, knowledge is certain to be either inferential or perceptual as captured in *Pramanavarttika (Commentary on Epistemology)*, "because there are two objects, there are two knowledge" (Dharmakirti, 2004).

Scientific Views

In the mid 19th century, Charles Darwin published his thoughts on the origin of life and the theory of evolution. After reading Darwin's *Origin of Species*, English political philosopher Herbert Spencer invented Social Darwinism. This ideology describes humans as competitive in nature, and the stronger the species, the greater their chance of survival and reproduction (Falk, 2020). Primatologist Frans De Waal said, "If strong varieties progress at the expense of inferior ones, this was not only how it was, Spencer felt, but how it ought to be. Competition was good, it was natural, and society as a whole benefited" (De Waal, 2009). Social Darwinists believe in survival of the fittest, and consider that some types of people naturally become powerful because they are innately better. Social Darwinism has been used to justify imperialism, racism, eugenics, and social inequality (History, 2018).

Gregor Mendel discovered genetics and inheritance after doing experiments on differently colored peas; concepts later used as a basis for eugenics. In *The Selfish Gene*, Richard Dawkins said, "the dominant features in successfully living genes are selfish and violent. This selfish gene makes the person selfish" (Dawkins, 2016). In the 18th century, when Social Darwinism was spreading in the west, Francis Galton started a new science to improve the human race by eradicating "undesirable genes." Adolf Hitler, one of the world's most notorious eugenicists, implemented Nazi-centered eugenic policies which considered Jews, Roma, Poles, Soviets, people with disabilities, and homosexuals inferior, and provided justification for the taking of innocent lives (History, 2018).

"Many neuroscientists have come to the conclusion that the mind is really the brain, or the mind is what the brain does. They claim that all our personal experience consists of brain functions, influenced by the rest of the body, DNA, diet, behavior, and environment" (Wallace, 2009). Neuroscience unveiled evidence for rationalists' claim of innate nature. For example, the Blue Brain Project (Pousaz, 2011) has proven that neurons send signals independent of personal experience. Neuroscientists estimate clusters of about fifty neurons are found in the brain at birth, and are fundamental to innate knowledge of simple workings of the physical world, acquired knowledge, and memory. Markram notes, “This could explain why we all share similar perceptions of physical reality, while our memories reflect our individual experience” (Pousaz, 2011).

In recent years, in the field of primatology, neuroscience, and life science, some studies have shown that compassion is not only innate to human nature, but also essential to human survival (Seppala, 2013). Mindfulness Based Stress Reduction is widely practiced, and has significant success in reducing stress. Furthermore, neuroscience research has shown that meditation on compassion yields greater benefit than mindfulness practices (Goleman and Davidson, 2017).

Modern sciences such as evolutionary biology, genetics, and neuroscience, unanimously identify and explain human nature by genetics. Biologist Edward Wilson said, “We are biological and our souls cannot fly free. If humankind evolved by Darwinian natural selection, genetic chance and environmental necessity, not God, made the species” (Wilson, 2004). Defining human behaviors based on genetics, and considering parental genes as the substantial cause of consciousness completely contradicts Buddhist views. Firstly, according to Buddhism, things arise from their substantial cause with the help of cooperative conditions. An object and its substantial cause must share similar properties, therefore genes cannot be the substantial cause of consciousness. Secondly, if parental genes determine a child’s health and mental condition, then it would contradict the karmic law by allowing unaccumulated karma to come to fruition and accumulated karma to go to waste.

Buddhist Views

Even though Buddhism does not specifically mention human nature, it considers all sentient beings with different levels of intelligence to equally have a Buddha nature and consciousness to be clear and knowing. His Holiness has said, “According to Buddhist psychology, consciousness in itself is neutral. It’s neither wholesome nor unwholesome, neither positive nor negative. Of course, it has the potential to be both, one way or the other” (Lama, 2002). All sentient beings have potential to acquire all the virtues of wisdom and compassion of a fully awakened Buddha. The first step of mind training in altruism, based on the seven-part cause-and-effect quintessential instructions for cultivating bodhicitta, is to recognize all sentient beings as having been one’s mother, as love towards one’s mother is innate (Lama, 2019).

The first of His Holiness’ four commitments focuses on the promotion of human values such as compassion, a part of basic human nature, without depending on religious explanations. His Holiness says, “My own view is very much based on empirical observation of how human life begins, how we depend so much on others’ affection throughout our lives, especially at particular points, and how we respond to affection both biologically and psychologically” (Lama, 2002). Since humans are social animals, compassionate care is essential and scientifically proven for their survival, especially a mother’s compassionate care for a newborn. Buddha mentioned that the possession of one dharma that equates to the possession of all dharmas is great compassion (Kamalasila and Vimalamitra, 1977). In Buddhism, compassion is the aspiration to alleviate suffering. In a sutra, Buddha said, “great compassion is the liberator of all sentient beings from all suffering” (Buddha, 2006).

Conclusion

Although creating a happy society is everyone’s wish, as 8th century Indian Buddhist scholar *Shantideva* mentions, “Although everyone wishes for happiness, due to ignorance, one destroys one’s happiness like an enemy” (Shantideva, 2008), meaning we acquire more suffering than happiness because we concentrate more on material richness than inner wellbeing. Ultimately, the solution is to nurture virtuous qualities such as love and compassion by developing an educational system founded on compassion reflective of scientific evidence. This will ensure that new generations will live happily. His Holiness has said, “If we think of our nature as essentially compassionate and cooperative rather than violent and competitive, we will tend to behave in certain ways” (Lama, 2002).

SUBATOMIC PARTICLES

Introduction

According to Buddhist philosophy, a subatomic particle is the smallest entity of physical form. Modern science states subatomic particles refer to elementary particles and subtler quarks. This essay focuses on the following questions. In Buddhism: How do subatomic particles exist? Are there differences between composite and elementary particles? What is the deeper philosophical basis for either advocating or rejecting the idea of a partless subatomic particle? What is the definition of matter? Is there a particle that is not any of the fundamental properties of earth, water, air, and fire, or their derivatives? In science: Do all particles consist of protons and electrons? What are the characteristics of an atom? Is there a substance before its experimental confirmation? In both Buddhism and science: Are the notions of matter “with parts” the same? Are the purposes of positing subatomic particles the same? Are there differences in understanding the formation of atoms? Are there ways to define a thing without relying on its parts? What are their views on the formation of gross level materials from atoms, and atoms from subatomic particles?

Buddhist and Scientific Views, and Their Comparisons

“Both Buddhism and science share methodological similarities, including a commitment to testing hypotheses about the nature of reality by repeated experiment” (Halliwell, 2009). Buddhist philosophy considers that both compounded or impermanent phenomena which are produced from causes and uncompounded or permanent phenomena which are not produced from causes are to be investigated (Hopkins, 2007). Science investigates all tangible things that one can see, hear, smell, feel, and touch, and the interactions of mass, energy, and forces. Investigation has been a main part of acquiring knowledge in both traditions.

Buddha said, “Bhikshus and the wise, just as a goldsmith tests his gold by burning, cutting, and rubbing, so you must examine my words and only then accept them, not merely out of reverence.” “The goal of science is to investigate and explain objects by using a unique inquiry method,” and Carl Sagan said, “science is not only a treasure of knowledge, but also a way of thinking” (Biaji and Lodoe, 2014).

Though scientific findings are the result of vigorous experimental processes, they are not guaranteed to be free of falsehood as rejection of a theory is also possible. In Buddhism something to be established as unquestionably existent must fulfill all three essential points: registered by a conventional consciousness; not contradicted by other conventional valid cognition; and not contradicted by a consciousness analyzing ultimate nature or whether anything exists by way of its inherent nature (Nganam, 2014).

All Buddhist philosophies accept ultimate truth and conventional truth. The building blocks of matter in the universe, i.e. the subatomic particles, belong to conventional truth. Identical or different types of subatomic particles come together to form matter. The subatomic particles are formed by earth, water, fire, wind, and their four derivatives, i.e. form, smell, taste, and tactility (Tan, 2009). All eight material particles are needed to form matter. For example, a cup of milk tea has particles with the obstructive quality of earth, the moistening quality of water, the burning quality of fire, and the moving quality of wind. It also has subatomic particles of color, smell, taste, and tactility. While an elementary particle is the smallest of all matter, an aggregated particle is the smallest of all aggregated matter. Moreover, an elementary particle is the lone initial particle, and an aggregated particle is formed by two or more elementary particles of the same chemical type, and composite particles are formed by particles of different chemical types (Jampalyang, 2013). The claim that though subatomic particles have potential to create shape and color they do not themselves have shape and color at a subatomic level, is a matter to be investigated. A subatomic particle is the smallest of matter, as Je Tsongkhapa said, “Particles that have been posited to be the smallest of matter cannot have parts such as east. As long as it has a directional part, it cannot be considered to be the smallest” (Tsongkhapa, 2019).

Buddhist philosophy considers a subatomic particle the smallest thing that makes up tangible matter. It is categorized into composite particles, aggregated particles, elementary particles, etc (Tsering, 2020). A subatomic particle functions as a substantial cause (main cause) or cooperative cause (causal conditions) giving rise to coarse physical objects by combining with other particles within the same group. Different schools of thought have different ways of understanding the nature of a subatomic particle in terms of it being partless, physically touching, and divisible. Although the two lower philosophical schools, which propound true existence, consider all subatomic particles partless and that they become part holders when touching one another, the Great Exposition School considers subatomic particles with gaps, while the Sutra School believes there are gaps between particles. The Mind Only School negates the existence of partless particles. The Middleway Autonomy School believes that ten physical realms are formed by the combination of subatomic particles, and that a subatomic particle has parts. The Middleway Consequence School thinks subatomic particles contain obstructions, as they obstruct others from coming in place, therefore they are unstable, dependently imputed, and compounded with eight elementary particles (Choesang, 2018). In Tantra, partless particles are rejected not only objectively but also subjectively.

According to science, a subatomic particle is the building block of matter and is categorized into quarks and leptons (Barberio, 2014). Whether a photon is a particle or wave is a topic of debate. Although science is based on measurement, it evolved from philosophical origins in the case of particles or the smallest building blocks of matter. Though the term atom means “indivisible” in Greek and it was considered the smallest of matter, the discovery of electrons, protons, and neutrons brought atomic research to a new level. Matter divides into solid, liquid, gas and plasma. Atoms bind together through chemical reactions to form all matter in nature (Hewitt, 2018). Some subatomic particles are as old as the universe and originated from the Big Bang (Hewitt, 2018). An atom is made up of protons, neutrons and electrons. While protons and neutrons make up the dense nucleus, electrons orbit around the nucleus in energy shells. The nucleons are made up of quarks (Barberio, 2014).

Although Buddhism does not have detailed accounts of subatomic particles like those demonstrated in measurable amounts in science, both traditions accept the notion of the material world forming from subatomic particles. His Holiness the Dalai Lama stated in a teaching that both science and Buddhism agree that our external material world is formed from subatomic particles. Thus, both traditions rely on experimental results to draw conclusions and develop theories rather than just follow hearsay. Though the unfindability of material existential fact in quantum science is similar to the indefinability of external objects in the Mind Only School, there is a difference, as quantum physics claims the existence of atoms and subatomic particles. During a teaching on the Fundamental Treatise on the Middle Way, His Holiness said that though scientists do not investigate the subtle and gross level consciousnesses, there are similarities between the scientific way of explaining existence of material things based on a specific object and Middle Way School’s claims about defining the nature of things by dividing matter into partless or with-part particles, and based on measurable things. As Buddhism understands the subtle level impermanence, on a particle level science claims that things are always vibrating (Lama, 2010). According to a commentary of *Abhidharmakosa*, seven subatomic particles form an atom, seven atoms form an iron atom, seven iron atoms form a water atom, and this sevenfold continues on to form particles of rabbit, sheep, elephant, solar ray, nit, louse, grain, and then finger’s width [inch] subsequently (Jampalyang, 2013). If we compare the total number of subatomic particles aligned in 1 m according to this theory, it surpasses quantum physicist Niels Bohr’s arrangement of 10 billion hydrogen atoms in 1 m. Moreover, the number of subatomic particles in a solar ray atom varies across different Buddhist texts, i.e. 343 according to *Lalita-vistara-Sutra*, 49 according to the *World Systems*, and 823,543 according to

Abhidharmakosa Root Text and Commentary (Gaden Podang, 2014). Therefore this has yet to be resolved by investigation.

Conclusion

Though the methods, goals, and philosophical backgrounds to investigate subatomic particles and atoms are different in science and Buddhist philosophy, I wish for a peaceful collaboration of knowledge based on open views, reasoning, and wisdom, as there are micro level particles as well as intangible consciousness that remain to be investigated.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

JG wrote The Basic Human Nature, LG wrote Subatomic Particles and DD translated the articles from Tibetan.

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Reflections on Physics Education and Communication with Tibetan Monastics

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Physics education research, a field that is now over 100 years old, has made it clear: the key to teaching physics successfully is to prioritize getting the concepts across, and the mathematical representation ("laws") can come later. On the other hand, conceptual representations are steeped in culture and language, while the corresponding "laws" are universal. The ETSI program provided a unique opportunity to re-imagine conceptual physics for Tibetan monastic culture. This perspective describes the major challenges derived from this experience over multiple areas of physics, and addresses two central questions: 1) how does the translation and interpretation of key terms such as energy, motion, charge, and system change the connotations surrounding physical laws? 2) What are the practical strengths and weaknesses of teaching conceptual physics using well-developed methods in the United States, and what can educators learn about the emergence of understanding?

Keywords: physics education, Tibet, physics demonstration, monastic culture, science education

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1 INTRODUCTION

From 2008 to 2013, the Emory-Tibet Science Initiative (ETSI) ETSI (2021) sponsored 36 science faculty, mostly from Emory University, to visit Dharamshala, India and deliver short 4–5 weeks courses in philosophy of science, physics, neuroscience, and biology. Building on the success of this program, from 2014 to 2019, ETSI expanded into its Implementation Phase by introducing a 6-year curriculum in these subjects, thereby establishing science education as part of the core curriculum of three major Tibetan monastic universities in India. Enrollment in the program grew from 345 in 2014 to 1,496 in 2019. By the end of the Implementation Phase, each university required two physics faculty for each year of study (Years 1–6). The faculty were recruited from a broad range of universities and colleges, primarily in the United States of America (United States). This perspective serves as a reflection of this experience, the communication challenges, and the major co-learned takeaways from a meshing of United States physics education with Tibetan Buddhist philosophy.

Throughout this article we use the term scholars to refer to the monastic students, both monks and nuns. The physics curriculum consisted of a selection of core concepts with a different focus each year: an introduction to the study of physics (Year 1), motion and mechanics (Year 2), thermodynamics and waves (Year 3), electricity and magnetism, and light, (Year 4), optics and modern physics (Year 5), and astronomy (Year 6). The primary reference was a Tibetan translation

FIGURE 1 | (A) Tibetan translations of physics terms. **(B)** At the end of 2-weeks course, a written, translated exam for each year of the program assessed the course. **(C)** Debates occurred nearly every evening, a key component of monastic education. **(D)** Scholars learn about static electricity with balloons. **(E)** Female year 2 scholars experimenting with forces as indicated on a scale. **(F)** An outdoor class on buoyancy in the swimming pool during Year 3. **(G)** Scholars used colored cards to answer physics concept questions. **(H)** Making large bubbles to highlight thin film interference of light. **(G)** Year 5 experiments included measuring diffraction with a laser pointer.

of a college-level physics textbook, *Conceptual Physics* Hewitt (2010). The ordering and choice of topics, as well as the choice of reference text, were all predetermined before the implementation phase. Thus faculty were charged with implementing this specific curriculum, but had freedom to choose instructional methods.

Typically, two translators were assigned to each class. Translators and faculty would meet to review the upcoming material (**Figures 1A,B**), yet most translation was done in real-time and was challenging for some concepts. For less experienced science translators, we adopted a nearly sentence-by-sentence method. A translator with more physics experience could present ideas more fully, serving more as a co-teacher and preventing some terminology misunderstanding and confusion.

Most physics faculty in the program (and all authors on this paper), chose active learning techniques typical of a modern undergraduate course in the United States. It has been demonstrated for United States undergraduates that physics learning happens most readily where students are actively engaged in course topics, via hands-on activities and peer-to-peer discussions Hake (1998); Meltzer and Thornton (2012). The active engagement aimed for in the physics classes was not dissimilar, in its goal, to some of the practices of Buddhist monastics, the most notable example is an exercise translated into English as "debating" (Dreyfus (2003)).

Debating involves two individuals or teams arguing opposing sides of a question, by drawing on knowledge and applying critical reasoning and logic. However, debates at the monastery bear little outward resemblance to formal debate as practiced in the United States. These are loud, physically active debates in an outdoor courtyard, with monks shouting over each other and slapping their hands together to relish a momentary victory or well-made point (**Figure 1C**). Intensive training in debate appeared to influence the way the scholars approached learning. Questioning was an important and celebrated part of the learning process. Since scholars relished challenging assumptions and probing arguments for weaknesses, we tried incorporating debate into our physics classes. For example, by Year 5, scholars had been exposed to many historical experiments and observations that fundamentally changed our understanding of the natural world. For example, one question posed for debate was: Is experimentation necessary for the advancement of science?

The remaining sections of this article focus specifically on the content and collective experience of the authors for each Year of study. Attention is paid to misunderstandings of foundational principles and learning styles that are distinct from those often found in undergraduate classes, although similarities will be discussed as well.

2 YEARS 1 AND 2

The Year 1 ETSI physics curriculum gave an overview of the field, introduced a wide array of topics and built excitement about the modules to come. Since mathematics is wholly integrated into the language of physics, the first course was also a place to identify and build quantitative skills that were important for engagement in future material. The Year 2 Mechanics course focused on motion, forces, and energy, and began to put these math skills to work. While most scholars found the operations of addition and subtraction to be intuitive, the physics curriculum also required facility with less-intuitive concepts such as negative quantities, powers and exponents, and direct and inverse proportionality.

Scholars were fascinated by more modern and advanced topics, such as special and general relativity and quantum systems. A significant communications challenge in the early years of the curriculum was connecting fundamentals to these more exciting topics where possible and emphasizing the connections across the field. This approach is consistent with best practices of physics education in the United States, aiming for a coherent view of the physical world across a wide range of phenomena Redish (2003).

In physics, terms like energy, momentum, displacement, etc., are used to describe motion and are specific in their definitions. These terms also describe specific ways for making sense of objects in motion. When translating these terms there are two challenges to overcome: 1) there may not be a word in the Tibetan language that corresponds closely to the physics term in English, and 2) the way motion is conceptualized in the Tibetan Buddhist philosophy may not map easily to how physicists think of motion.

In a survey conducted after the 2019 Mechanics Year 2 module, scholars were asked "When you kick a ball off the ground, why does the ball continue to move after it left your foot?". Physicists would answer the question with the concept of inertia, and with momentum and energy, imparted to the ball by the foot, that remain with the ball in flight. A typical response by the monastic scholars was to acknowledge inertia, but also focus on the notion of impetus, that the "kick force remains continuously to make (the ball) move". This is not dissimilar to typical introductory physics classrooms in the United States, but Year 2 scholars may have also been grappling with the complex notion of causality in Tibetan Buddhist philosophy in addition to making sense of physical motion Kalupahana (1975).

For physicists a force is an action that, in the case of the kicked ball, is short in duration. The momentum and energy of the ball are properties of the object affected by forces. In the Tibetan language, energy and force may be used interchangeably, presenting a translation difficulty that exemplifies the challenge of communicating and translating in real time without preparation. Cultural conceptions of the world also need to be explicitly taken into consideration to make the translation meaningful Aikenhead and Jegede (1999); Redish (2012). Similarly, in the undergraduate physics classroom, acknowledging students' current conception of motion before proceeding to explore the physicists' consensus on the topic is recognized as a best practice Novak et al., 1999.

It is increasingly common in undergraduate science teaching to take a hands-on, experiential approach that connects theoretical concepts to practical applications Hake (1998). Wherever possible within the constraints of available materials, we integrated hands-on activities to help build intuition about physical systems. With an activity, students can ask and answer questions arising from basic curiosity, and immediately test predictions. For example, electric charge is not a visible quantity, but the scholars could build up charge on the surface of a balloon, and experience the results (**Figure 1D**). Wheeled carts helped scholars experience motion and relate, for example, force and acceleration. Scholars pressed on a scale to gain intuition with applied forces and reaction forces (**Figure 1E**). With practical activities, scholars could pose and answer questions in a learning-focused environment, helping overcome potential barriers to questioning a teacher perceived to be an expert.

3 YEARS 3 AND 4

The Year 3 curriculum introduced the scholars to properties of matter, building blocks such as atoms, molecules, chemicals, and the periodic table. One major piece of introductory material was understanding large numbers. Questions such as "How many molecules are there in a water drop?" led to philosophical discussions of breaking matter into constitutive parts, and how to represent large numbers with scientific notation, an utterly foreign concept that is central to United States curricula. Concepts such as heat, temperature, and pressure laid the foundation of thermodynamics. Energy was a common thread that ran through Year 3's discussion. Although energy is more intuitive since it represents a quantity that can change forms, there were some foundational misunderstandings, for instance, colder temperatures represent a lack of energy. Touching a cold object makes your skin cold, suggesting that something from the cold object has transferred to your skin, which is incorrect.

Another misunderstanding centered on geometrical concepts such as area and volume, especially when discussing pressure and density. This was illuminated during lessons on buoyancy. During one lesson, scholars visited the nearby swimming pool to do laboratory experiments on sinking and floating, as shown in **Figure 1F**. Prior to this, nearly all agreed that a heavier person, as measured by their mass, would sink in the water, and a smaller, lighter person would float. This myth was dispelled by direct experimentation in the pool with scholars, and by placing marbles and plastic balls in sealed water bottles.

The last third of the Year 3 curriculum focused on waves: sound, light, water, and the transfer of energy. Hands-on demonstrations included standard stretched "slinkys" and ropes, yet discussion surrounding more familiar topics such as earthquakes, musical instruments, and religious chanting always received more attention. Conservation of energy was a cornerstone concept that helped tie together thermodynamics and waves, for example, light from the Sun heats up the Earth.

The year 4 curriculum covered the topics of electricity, magnetism, and light. The mornings consisted of lecture/ discussion, and the afternoons were devoted to labs in small groups. Many of the labs involved the use of electricity and magnetism kits Chabay and Sherwood (2018) which had items such as light bulbs, switches, compasses, and magnets. While the scholars enjoyed building motors and understanding circuits, most topics in Year 4 have little payoff in terms of the bigger ideas that excite them, such as quantum physics and cosmology. This was a weakness of maintaining our familiar teaching sequence, as discussed further in the summary section.

Translation affected interpretation in some contexts, such as a circuit "switch," which was translated as "gate." This small difference led to an opposite interpretation of whether current flows when "open" and "closed". Additionally, observational evidence provided better explanation and insight than mathematical definitions. For instance, scholars constructed circuits that directly connected voltage with number of batteries, and current with light bulb brightness. This made Ohm's Law, an abstract equation, become obvious. In the case of "color," the translation was the same as "color" in Tibetan. While this allowed the scholars to identify the topic, the concept of color in Buddhist philosophy is inherently different from the way physicists conceive it Black is a color in Buddhism, whereas in the physical definition of light, black is the absence of light. Therefore, the monastics had to separate these two definitions of the same word.

A well-tested method of enabling conceptual understanding in the American classroom is to use Conceptests, also sometimes called "Think Pair Share" questions Mazur (1997); French and Prather (2018). The scholars were asked a multiple choice question, and polled for their own answer (**Figure 1G**). They then discussed their choice with a neighbor, and the class was re-polled before the correct answer was revealed. American students are initially hesitant to participate, and some students are often easily convinced by confident neighbors. However, the monastic scholars embraced this method, and were accepting of conflict with their peers, likely due to the focus on debate and interactive discussion in monastic education.

4 YEARS 5 AND 6

Years 5 and 6 included three main topics: optics, modern physics and astronomy. By these years, the scholars benefited from having a substantial base of science knowledge. As a result, scholars could practice generalizing previous knowledge and applying it to novel situations. Equally importantly, scholars were now well acquainted with scientific ways of knowing and our pedagogical stylistic choices were more familiar. This allowed for smoother transitions to experiential learning and for less need to signal and support the direction the science was taking. The class lectures involved concise, distilled concepts optimized for ease of translation. This precision became particularly important when covering inherently challenging topics such as wave-particle duality and the Heisenberg Uncertainty Principle. Questions posed to the scholars were meant to generate discussion and explore misconceptions.

Optics is naturally visual, and the ability to support concept development with photos, videos, demonstrations, and labs helped engage the scholars and likely minimized some of the translation issues inherent in other parts of the curriculum. Scholars participated in investigations of visible light with polarizers, mirrors, lenses, soap bubbles, and pin-hole cameras they made out of cardboard boxes (**Figures 1H,I**). Ultraviolet sensitive beads and an infrared camera provided opportunities to experiment in non-visible portions of the electromagnetic spectrum. With optics, we found that talking about everyday objects from a physics perspective resulted in thoughtful and challenging questions, such as, "When you look in a mirror, you see yourself. Is it possible to actually see a mirror?" In modern physics and astronomy, investigations necessarily relied upon modeling, including computer simulations, a coin-flipping exercise to demonstrate radioactive decay rates, and a stretched rubber sheet to represent the warping of space-time around massive objects.

Some concepts of modern physics generated stimulating discussions because of their relationship with the monastics' understanding of the nature of the universe and the Buddhist idea of causality. Nuclear decay and the Big Bang theory are examples. In nuclear decay, a statistical understanding of when a nucleus might decay agrees with the Buddhist idea of "very hidden phenomena" that cannot be directly perceived. We also found that the monastic scholars had much less trouble than our typical undergraduate students with many of the concepts from relativity. In Buddhist philosophy, ultimate nature is called "emptiness," or the lack of absoluteness, which is consistent with the lack of absolute length and time in the theory of relativity. Overall, many scholars seemed excited to have reached the point where the ideas of quantum physics and relativity were introduced, and particularly enjoyed trying to integrate these new concepts with their previous knowledge and experience.

One pedagogical technique that did not work as anticipated was introductory motivational questions. To pique interest in and generate some preliminary ideas, a question such as "What do you think causes sunspots?" might be posed. More often than not, these questions were so compelling that scholars tried to explore all the possible answers and moving scholars back to the lecture at hand felt like a disservice to their curiosity. Eventually, the most interesting questions were culled in favor of smaller, bite-sized questions that were carefully placed where they could be easily answered based upon previously presented information.

Something is undoubtedly lost with this modification, but we found it necessary to make this sacrifice in order to complete the curriculum.

SUMMARY AND DISCUSSION

There were two main takeaways from teaching the ETSI physics curriculum to these scholars. High-engagement pedagogy worked well, based on feedback we received from the experienced translators and from scholars who attended multiple years of classes. Since we could not use the "crutch" of mathematical equations, we had to rely on demonstrations, hands-on experimentation, and active discussion/debates, which is commensurate with the way Buddhist philosophy is taught. In Buddhism, all scholars work on three main areas: the base, the path, and the result. The base is hands-on reality, whereby demonstrations and experiments facilitate the path towards enlightenment. By construction, this pedagogy engaged the scholars, which we observed to stimulate their appetite for understanding.

Secondly, translation was a challenge, broadly speaking. Many physics terms were only newly translated into Tibetan, and some chosen translations had linguistic baggage (e.g., gate vs switch). Some physics concepts were unfamiliar to some translators, and so this was a challenge for simultaneous translation. Nevertheless, due to their monastic training, the scholars tended to ask many questions, and so most translation issues were addressed. Some questions that undergraduate students might have hesitated to ask, for fear of seeming elementary, nonetheless prompted rich discussions and important clarifications with monastic scholars. Other questions were deep and sophisticated, trying to probe at the nature of reality itself. Regardless, the scholars took ownership of their own understanding, and the teacher was there to be a guide, not to profess.

Based on these qualitative observations, we suggest that incorporating keystone Buddhist traditions, such as doubting core concepts and debating, would benefit undergraduate classrooms in the United States, which too often rely on assimilation of material rather than in-depth discussions. Teaching physics conceptually to Buddhist scholars provided us with a vivid reminder of the importance of connecting with students at the cultural level and linking the students' lived experience with physics concepts. This too applies in the United States, recognizing that students within our society come to the physics classroom with unique sets of beliefs and experiences.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

JBe, JBu, MaK, MiK, AL, JZ, and KN all equally contributed to the writing of the article based on their experiences in the ETSI program. TT provided crucial oral and written insight during the program and during the writing process.

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De-Centering the "West" in Cross-Cultural Philosophy: Philosophical Pedagogy in the Emory-Tibet Science Initiative

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This article explores the author's experience teaching in ETSI as an instance of a cross-cultural intellectual encounter. It develops an account of cross-cultural encounters as defined by two moments: first, a moment of cultural shock when the encounter rebounds on the self, leading one to question one's assumptions about the world; and second, a moment of possibility where the self, after interrogating its own ways of thinking, can pivot to accommodate a detour from its past disciplinary and cultural habits. Here, the authors use the writings of the Argentinian feminist theorist María Lugones and the North American philosopher Frederick Elliston to clarify the nature of these moments.

Keywords: cross-cultural philosophy, cross-cultural communication, Eurocentrism, Buddhism, ETSI

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INTRODUCTION

In this article, we use our experience as faculty in the Emory-Tibet Science Initiative (ETSI) to reflect upon the epistemic significance of cross-cultural intellectual exchange. We examine a question we received multiple times during our 4 years teaching philosophy of science in ETSI: *Do you think science will make you happy?* The subtle yet profound critique of "Western" intellectual culture embedded in this question disrupted our habits of thinking in productive and meaningful ways. In our view, cross-cultural encounters such as the one enacted through this kind of question are defined by two moments: first, a moment of cultural shock when the encounter rebounds on the self, leading one to question one's assumptions about the world; and second, a moment of possibility where the self, after interrogating its own ways of thinking, can pivot to accommodate a detour from its past disciplinary and cultural habits. In what follows we use the writings of the Argentinian feminist theorist María Lugones and the North American philosopher Frederick Elliston to clarify the nature of these moments and consider how they showed up in our experience of teaching in ETSI.

ETSI: A PRIMER

In 2014, we joined the faculty of ETSI, a program "committed to bringing together the best of the Western and Tibetan Buddhist intellectual traditions for the creation, development and dissemination of knowledge and practices that will benefit humanity" (The Emory-Tibet Science

Initiative 2020). ETSI was originally piloted in 2006, when His Holiness the XIV Dalai Lama invited scholars from Emory University in Atlanta, Georgia, to collaborate with the revered Library of Tibetan Works and Archives in Dharamsala, India. Seven years later, the second phase of the program was launched with the aim of implementing a comprehensive modern science curriculum at Sera, Gaden and Drepung monastic universities, with scholars from North American and European universities fanning across Tibetan settlements in South India, working closely with advanced monastic scholars and administrators to equip these universities to implement their own science education programs *in situ*. This historic and ambitious program offered courses in philosophy of science, biology, physics and neuroscience to advanced monastic scholars. The course we taught introduced these scholars to historical and contemporary debates in the philosophy of science as a way of priming their thinking for the concepts and ideas they would eventually encounter in the science courses that would follow. Some of the philosophical themes covered were falsification versus confirmation, inductive versus deductive reasoning, causation versus correlation, the nature of scientific observation, scientific realism versus antirealism, the social context of science, and the limits of science. The goal was to give our students a broad, albeit brief, introduction to the types of questions Western philosophers pose about scientific thinking.

Teaching this material in this context was profoundly enriching, to a large extent because our students—who were accomplished philosophers in their own right—approached the problems we introduced and questions we raised in ways that were novel to us. Indeed, before landing in India we were told by the monastic scholars who prepared us to "expect the unexpected" -- that is, to expect different styles of thinking, discussing, and debating than what we usually get from university students in the United States. After all, our monastic students had very advanced philosophical training -- in many cases much more advanced than ours -- but were unfamiliar with the basic principles of scientific practice that those teaching in Western-style universities may take for granted.

Of the unexpected, there was plenty. There were questions that took us some time to fully understand, as well as questions that we understood but didn't know how to answer. Here, we would like to focus on a specific question we encountered every year we taught in ETSI, a question that we now see as exemplary of both the challenges and promises of cross-cultural philosophical encounters. Each summer, our students were eager to know, "Do you think science can make you happy?" While the question might seem misplaced or perhaps just a bit strange to a Western philosophical audience, there is a lot more packed into it than appears at first blush. Indeed, this question -- and the conversations it prompted among us, our students, and our translators -- models the transformative potential of cross-cultural dialogue. By putting us in the position of questioning fundamental assumptions about our discipline and the "Western intellectual tradition" more broadly[1], this question forced us to take a detour from our disciplinary and cultural habits. In the possibility of this detour, we argue, lies the transformative epistemic power of cross-cultural intellectual encounters.

WHAT'S IN A QUESTION?

The straightforwardness of our students' question might make it easy to overlook the deep philosophical stakes beneath it. As we came to learn through conversations with our monastic students and translators, the question of whether a philosophical or intellectual tradition can deliver not only academic rigor but also soteriological transformation—that is, true, absolute happiness—was of paramount importance to them.

This is due, at least in large part, to the fact that Buddhism was founded on this kind of soteriological mission. The Buddha's first teaching after he attained enlightenment—known as the Four Noble Truths—was a diagnosis of the human condition as beset with suffering (Tibetan, Wylie: duk nghal) and an account of the path of ethical behavior, meditative practice and epistemological reorientation that leads to liberation from this suffering (see Thanissaro Bhikkhu 1993). The many Buddhist traditions that unfurled from that first teaching by the Buddha Shakyamuni some 2,600 years ago—including the many intricate philosophical exegeses, debates and commentaries of the Tibetan canon that comprise our monastic interlocutors' intellectual tradition—all maintain that soteriological aim as

[1]We use the term "Western intellectual tradition" advisedly. We are cognizant of the fact that there is, in fact, no single, monolithic "Western intellectual tradition" seeing as intellectual activity in Europe and North America has long been intercultural, multidisciplinary, and heterogeneous in method and orientation. This activity, moreover, has in no way been exclusively defined by scientism. For instance, since the 17th century multiple Western philosophical lineages have been critical of the West's adoration of scientific rationality. In the 19th century, hermeneutics was founded upon the distinction between the "explanations" that science can furnish about the natural world and the broader "understanding" that only philosophy can give us about the meaning of human life and human affairs. Around the same time, German romanticism called for a return to nature and innocence largely out fear that the increasing "rationalization" of the world at the hands of science and technology would extinguish the creative, imaginative, and intuitive powers of the human spirit. Later, in the 20th century, other schools—such as phenomenology, existentialism, Critical Theory, pragmatism, as well as various stands of applied ethics—would similarly argue that one of the tasks of philosophy is to reflect upon the limits of science. Nonetheless, even if we recognize that not all Western intellectual activity is rooted in scientism, the majority of our students identified science as largely coextensive with Western thought itself. From their perspective, we were invited to their monastic universities as exponents of "Western" ways of thinking, especially scientific reasoning. Granted, this may have been a function of the structure of ETSI as a program that explicitly foregrounded science as *the* essential cross-cultural element to be integrated into monastic education. In any case, when we say that our cross-cultural philosophical encounter in ETSI made us rethink the "Western intellectual tradition," this is in part because through ETSI we were made newly aware of the way in which we were placed within the narrative surrounding that tradition by seeing ourselves as our interlocutors saw us.

the core of the tradition. Even the most arcane and technical epistemological and metaphysical expositions of Buddhist philosophy ultimately come back to the goal of liberating sentient beings from suffering. It is this substantive understanding of happiness—as liberation from suffering rather than as worldly pleasure or mundane satisfaction—that informed our students' question, since they viewed the attainment of happiness as the ultimate purpose of the Buddhist tradition they have devoted their entire lives to systematically understanding[2].

We were brought to India to impart the fundamentals of modern scientific thinking precisely because science has been identified—by His Holiness the XIV Dalai Lama and others—as a singular offering of Western intellectual culture, the *lingua franca* of the modern West[3]. Hence, when our students asked us whether we believed science could make a person happy, we came to understand that what they really wanted to know was whether we shared their soteriological mission and whether we had spent time reflecting upon the soteriological value of the intellectual method, discipline, and culture that we were there to teach. In short, they were asking: *what, in the final analysis, is the value of the things on which you, as Westerners, spend so much of your time and cultural resources? Do those things liberate you from suffering? And if not—what is the final aim of what science does and what you do?*

Of course, our students are not the first or the last to inquire into whether science (and, by extension, much of the standard approaches of European and North American intellectual culture) has the tools to address the most pressing human problems. For instance, the philosopher of science Nicholas Maxwell is known for his critique of the inadequacy of North American and European academia when it comes to meeting the enormous ethical and geopolitical challenges of the twenty-first century. Maxwell distinguishes the generation of *knowledge* from the imparting of *wisdom*. He argues that while Western spaces have proven their lot relative the first, they have failed tragically at the second, which incidentally is what this moment in our planet's history so desperately needs. On his view, Western intellectual culture teaches facts that allow one to identify the most effective means to reach an end, but it neglects to impart the ethical orientation that enables one to reflect upon the ends themselves. Maxwell makes an urgent call for a revolution in Western academia, reorienting its goals from the acquisition of knowledge to the cultivation of wisdom (Maxwell 2007; 2012; 2014). Although he almost surely does not have an aim on par with Buddhist soteriology in mind as the ultimate outcome of what he calls wisdom-inquiry, his point nonetheless resonates with the gentle but precise critique we heard from our students that as far as they could tell, for all its accomplishments, North American and European intellectual culture—and this includes science and philosophy of science—does not seem to be working toward what are actually the only questions that really, *truly* matter.

THE EPISTEMOLOGY OF CROSS-CULTURAL DIALOGUE

Although our monastic students' question and Maxwell's critique both interrogate the soteriological stakes of science and technology, inasmuch as these critiques—rightly or wrongly—both identify science as the predominating force in European and North American thought, we take their critique not only as a challenge to science but also to Western academic culture generally, including the practice of our own discipline of philosophy. Being faced with such a simple but profound question as whether science can make a person happy (in the substantive, soteriological sense) prompted us to re-examine the fundamental values that undergird our work as philosophers. By drawing into relief an unexamined premise of our profession and, indeed, our identities as North American academics, this kind of cross-cultural encounter dislodged our habits of thinking in important ways. To analyze the epistemology of that moment, in this section we briefly turn to the philosophers María Lugones and Frederick Elliston, who provide conceptual tools for describing the epistemic impact of cross-cultural philosophical exchange. Their concepts—of "world traveling" in Lugones and of the dialogic model of philosophical contact in Elliston—elucidate the epistemic significance of how our students' inquiry disrupted, disoriented, and ultimately enriched our thinking about the nature of our own philosophical activity.

The feminist philosopher María Lugones coins the term "world-traveling" to describe the experience of entering into genuine dialogue with those who do not share our perspective and making a concerted effort to see the world as they see it (Lugones 1987). World-traveling shifts our epistemic frame of reference as we catch a glimpse into "what it is to be them and what it is to be ourselves in their eyes" (Lugones 1987, 17). By familiarizing us with the strange and by estranging us from the familiar, she suggests, world-traveling stands to disrupt even our oldest, most sedimented patterns of thought. Lugones contrasts world-traveling with what the feminist theorist Marylin Frye calls "arrogant perception," a mode of relating

[2]Affirming this point, the social psychologist Heidi Levitt examines the monastic curriculum undergone by thirteen Tibetan Buddhist monks in Dharamsala, India, identifying the primary aim of Tibetan Buddhist monastic education as the cultivation of wisdom (as defined in Māhāyana Buddhist sutras on the perfection of wisdom, or prajña-paramitā) (Levitt 1999). Levitt's analysis focuses specifically on the nature of the wisdom that her subjects' education aimed to cultivate, but for our purposes, it is telling that in Buddhist epistemology, the perfection of wisdom is in fact co-emergent with the "mind of enlightenment" (Tibetan, Wylie: byang chub kyi sems). Wisdom and liberation are very closely tied together, if not inextricable. This points to the vast soteriological aims that contextualize Buddhist monastic education and even these monks' understanding of what it means to be "learned."

[3]To be clear, we do not abide by a reductive East-versus-West dichotomy according to which "the West" is the locus of scientific and critical rigor while "the East" is the cradle of mysticism and spirituality. For starters, there is a long history of intellectual traditions that have grown, and continue to grow, out of the West that view philosophy as driven primarily by the question of the good life. Moreover, many schools in East and South Asian philosophy rival Western philosophy of science in their rigor, precision, and commitment to logic. One of them is Buddhism itself. Another is the Indic philosophical system of Nyāya (from the Sanskrit for "method" or "judgment"), which foregrounds questions of knowledge (Pramāṇa Shāstra), the structure of inference (Tarka Shāstra), and the science of critical inquiry (Anvikṣhi). All of this is to say that scientific thinking is not the sole purview of Western thought. Even so, the fact remains that underwriting the mission of ETSI was the belief that Western science is the key cross-cultural training required of the "twenty-first century monk."

to others whereby one instrumentalizes them by pressing them through the screen of one's preconceived notion of who they are. In arrogant perception, one "grafts the substance" of another person onto oneself, limiting their singularity (Lugones 1987, 4). Although Frye originally used this concept to name how men perceive women under patriarchy, Lugones reminds us that arrogant perception occurs along cultural lines as well, fostering in members of a dominant culture a dehumanizing indifference to the worlds of others (or an interest motivated by a will to master). By contrast, world-traveling gives way to playful curiosity about the lives of people who inhabit worlds different from our own, a curiosity that, by allowing us to momentarily see ourselves through new eyes, makes possible a more meaningful bond between self and other.

If Lugones' view of world-traveling clarifies the epistemic impact of being made strange to ourselves through an encounter with another way of thinking, the work of the philosopher Frederick Elliston highlights the importance of critically reflecting upon the intentions that philosophers hold when fostering philosophical conversations in unconventional spaces (Elliston 1983)[4]. He notes that, since the 1950s and 1960s, philosophers in North America have been "bringing philosophy" into a variety of unconventional spaces: "hospitals, clinics, old age homes, government agencies, high schools, private industry, independent research centers, prisons, police academies, and counselling centers" (Elliston 1983, 197). Elliston argues that there are two prevailing models for how philosophers tend to position themselves in these non-traditional settings. On the "missionary" model, philosophers are proselytizers who arrive in new spaces with the express intention of initiating "the locals" into their way of thinking. This model treats philosophers as subjects whose epistemic and moral authority is absolute—or at least unrivaled by that of their interlocutors—and whose task it is to enlighten, but not be enlightened by, those they might encounter. The counterpoint to the missionary model is the "social scientific" one, which assumes that philosophers can enter new spaces wholly undetected and leave them in the same condition in which they found it. Rooted in the scientific fantasy of the observer who sees everyone but is seen by no one, this model ignores how the observer is always an influence, a contaminant that alters the dynamics of the object they seek to analyze[5]. Despite their differences, Elliston says, both of these models share one fundamental error: they assume that the philosopher enters into these spaces of "otherness" either to change or to observe their interlocutors, but never to be changed *by* them.

Elliston ventures a third possibility for how philosophers who depart from the manicured confines of the Western university can approach their interlocutors: a "dialogic" model of positioning oneself in relation to others without assuming the supremacy of the self. Although he does not develop it in detail, Elliston claims that the defining feature of the dialogic model is that it "expands one's perspective to include others" (Elliston 1983, 201). On our reading, those who embrace this dialogic approach to cross-cultural communication recognize the limits of their perspective and strive to see things from the perspective of others to the extent that this is humanly possible (and in a manner reminiscent, in our view, of Lugones' world-traveling). Rather than assuming a position of epistemic or moral authority over others, dialogic philosophical pedagogues question their faith in their own epistemic and moral standing and are "brave enough to admit [their] biases and limits" (Elliston 1983, 202–203)[6]. This kind of dialogic encounter, Elliston insists, precludes pontification and requires careful listening[7].

Together, Lugones' concept of world-traveling and Elliston's dialogic model of philosophical conversation underscore what we stand to gain from genuine cross-cultural encounters. When we venture outside of our habitual, culturally familiar paradigms, we are allowing ourselves to be made strange to ourselves. Seeing ourselves and our ways of thinking and being through a new lens, with a different sense of freshness and clarity, we can appreciate dimensions of ourselves that had disappeared from view and escaped our explicit attention. In other words, we can know ourselves—including our epistemic gaps, assumptions, and biases—more fully. Meanwhile, the model of a dialogic encounter illustrates the necessity of entering into novel philosophical spaces with the expectation of being changed by them. In our case, as ETSI instructors, avoiding the errors of the missionary and social-scientific models means approaching the encounter in a spirit of mutuality and receptivity, knowing that the integrity of that encounter rests upon our willingness to be decentered, disoriented, and ultimately enriched by the dialogue that ensues.

CONCLUSION

All of this speaks to what we argue is an essential component of cross-cultural philosophical dialogue, which is a readiness to accommodate detours from our own disciplinary and cultural habits. Cross-cultural dialogues are not a neutral "sharing of

[4]Although Elliston's article deals not with cross-cultural philosophical encounters but with philosophical conversations with non-academic interlocutors in non-academic (but still Western) settings, his line of inquiry provides a useful framework for analyzing our experience doing philosophy cross-culturally in ETSI by discussing a different form of world-crossing that is still relevant to understanding cross-cultural philosophical encounters

[5]As Elliston puts it: "Social scientists frequently decide to adopt a posture of non-interference. Because their overriding commitment is to the pursuit of truth, they seek to minimize the extent to which their presence alters the situation they wish to observe. Missionaries on the other hand typically adopt just the opposite stance: they take part in the affairs of others in order to lead them from their evil ways. Their ultimate goal is to save their souls, and they exercise all their personal skills and resources to this end" (Elliston 1983, 199).

[6]Gouinlock (1979) similarly notes that as philosophy educators "we must recognize our limitations" (48).

[7]Vaidya (2015) makes a similar argument. Arguing that comparative philosophy would be well served by adopting a directional shift toward public philosophy, he claims that public philosophy can take two modes: the "philosophy-to-public" direction, in which philosophers enter non-academic spaces for the benefit of the public; and the "public-to-philosophy" direction, in which members of the public take up philosophy in a public space for the benefit of all. While the "philosophy-to-public" direction resembles Elliston's "missionary" approach, the "public-to-philosophy" direction "assumes that philosophy as a discipline could require directional navigation from the public" and "recognizes that for philosophy to evolve in a relevant and meaningful way over time it must not only be prepared to *analyze for*, but also to *attend to*" (Vaidya 2015, 5, 39). See also Vaidya (2012; 2014).

information," much less a "gift" from Western academics to uninitiated Others. Rather, they are opportunities to be displaced, disoriented and thereby transformed. Epistemic events like these necessarily rebound back upon all those involved in the conversation, unseating the fundamental assumptions that underwrite the conversation itself. For us, being willing to adopt our students' critical perspective about the nature and goals of science–and even our training in Western philosophy—allowed us to appreciate more holistically a subtle critique of the values of the Western intellectual culture in which we were trained, putting necessary and fruitful pressure on our own thinking about what philosophy is and is *for*.

It should be noted that the question that we faced repeatedly in ETSI—*Do you think science can make you happy?*—did change us, prompting us to deepen our understanding of what it is we hope to impart through our philosophical practice. Although we hardly would adopt a stance of guru or liberator as philosophy instructors on the model of a Buddhist teacher, we do take seriously the challenge that philosophy should meaningfully enrich the inner lives of those who participate in it, actually cultivating wisdom rather than simply leading to the accumulation of knowledge[8]. This means that we, as philosophy professors, should seek at the very least to serve as inviting guides to our students, aiming to foster wisdom in our students and help them orient themselves in the direction of a better life.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

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[8]In an article published in 2018 in *Teaching Philosophy,* the philosophers Brian Bruya and Monika Ardelt express a similar sentiment regarding the importance of using philosophical education to inculcate wisdom. They identify five components of wisdom pedagogy: challenging beliefs, prompting the articulation of values, encouraging self-development, encouraging self-reflection, and cultivating moral emotions (Bruya and Ardelt 2018). Bruya and Ardelt, however, note that these are precisely what is often missing from traditional philosophical instruction, especially in formal, academic settings. "Perhaps reflecting a general uncertainty about the practicality of fostering wisdom in formal education, the existing literature on theories of wisdom pedagogy is not extensive," they say (Bruya and Ardelt 2018, 240).

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Check for updates

Translating Monastic Lessons to Teaching Undergraduate Biology

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My participation in the Emory Tibet Science Initiative (ETSI) has afforded me considerable means to enrich my teaching at the undergraduate level. Here, I discuss how I translated lessons learned from working with Tibetan Monks to teaching in a primarily undergraduate institution, including: 1) introducing each course with a challenge to the assumptions made as "Western scientists" 2) using the unique monastic pedagogy of debate to facilitate classroom scholarship, and 3) embracing compassion as a central tenet to engage and empower student learning, which has become the cornerstone of my teaching philosophy. In addition, I brought undergraduates with me to participate in ETSI, and the experience had a profound effect on their educational and career paths. These experiences with the Tibetan monks transformed my teaching and continue to inform how I approach undergraduate education.

Keywords: tibetan monks, primarily undergraduate institution, introductory biology course, inclusive pedagogy, ETSI, tibetan debating

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INTRODUCTION

At first glance, my teaching at the University of Richmond (UR), a primarily undergraduate institution (PUI), and the teaching I did with ETSI at Sera Jey Monastery in Bangalore, India, appear to have stark differences (ETSI, 2021; Gray & Eisen, 2019). In a typical UR class, I teach in English to about 18 students at a time who are from the ages of 17–21, all sitting at desks or lab benches using a variety of student-centered group work activities with inquiry-based labs (**Figure 1A**). At the monastery, I taught through an interpreter to 75–80 Tibetan monks of various ages, all sitting cross-legged on the floor in their maroon robes, while I wrote on a portable white board or presented slides and videos projected on the wall of a large room (Gray & Eisen, 2019). While these differences are pronounced, what I came to realize as I alternated between the two situations over a 6-year period is how similar these experiences actually are–and how they provided concrete lessons that I ultimately translated from the monastery to my classroom at UR.

For me, teaching science is about asking questions. Posing questions and exploring answers with my students is fundamental to my roles as a science educator. And in turn, the spark that comes when students ask questions that show that they have gained a new insight about life is a very meaningful moment for me and for them. In many ways, teaching and learning is the same across vastly different contexts, and my experience with the monastics has led me to explore how this work informs how I teach biology to undergraduates.

"What Is Life?"

When I first went to India to teach and learn with the Tibetan monks in the summer of 2014, I did not know what to expect, and leaned heavily on my co-teacher who had previous teaching experience there. The prompt we used to launch our first session with the monks was "What is life?" and from there we moved to "What makes something alive? What makes something 'not alive'?" As we began

FIGURE 1 | Comparing the undergraduate PUI teaching experience to teaching monks. A typical classroom at the University of Richmond **(A)** compared with a typical classroom at the Sera Jey monastery in Bangalore, India **(B)**. Smaller classroom sizes allow for active participation in determining "what is life" **(C, E)** but similar learning objectives can be achieved through large lecture techniques **(D, F)**. Debate can be incorporated into the undergraduate classroom **(G)** and is essential to monastic learning **(H)**. Written informed consent was obtained from the individuals for the publication of identifiable images.

to think about these topics, I remembered a book my father gave me when I was in high school: *What is Life?* by Erwin Schrodinger ("Schrodinger, Erwin. What Is Life? New York: The Macmillan Schrodinger, 1945. 91 p. $1.75," 1945). Just as Schrodinger's book sparked my interest in how we approach fundamental biological questions, these questions inspired remarkable discussions at the monastery. Even though I had prepared to be sensitive to cultural differences, the initial questions from the monks flustered me a bit and I found myself in a position of defending Western biological "settled science" that we often assume undergraduates know. I was able to recover my footing by explaining how scientific theories are built. As we discussed the scientific method by which experiments are controlled, data are analyzed, and theories are built, some of the intellectual tension was relieved.

An example of this occurred during one of the early "Question and Answer" periods, when a monk questioned my use of chickens as an example about how genetic material is passed from parents to offspring. He assured me that he knew of a rooster that was able to produce eggs and that my claim that only hens lay eggs was incorrect. I was perplexed by this and immediately denied this possibility, which led to a conflict as he insisted that I was wrong—that he had seen a rooster lay eggs. After reflecting on this conversation that night, I decided to take a different tact the next day. I brought up the example again and asked, "How would a scientist prove that roosters can lay eggs?"

Together we talked about how we would set up this experiment: What conditions would we keep the roosters in? How many roosters would we use? What would be our controls? Suddenly our topic was no longer arguing the "fact" of whether roosters can or cannot produce eggs, but we were exploring how science can lead to these "settled" theories.

By contrast to classes at a monastery, most scientific courses at the undergraduate level do not deal directly with potential epistemological conflicts. Students who take a first-year biology course at the University of Richmond or any Western university have been exposed to the definition of a living thing at some point in their middle and high school education—often through rote memorization and without an analysis of the topic in a deeper way. But, following from the teaching I have done at the monastery, I have found it more productive and engaging to start my undergraduate courses with a fundamental question like, "How do you know what a living thing is?" Such inquiries do two things: First, they force our students to immediately start questioning some of the dogma that can permeate biology education. Second, these initial challenges allow me to discuss concepts that are core to biological teaching and learning, such as hypothesis testing, repetition of experiments, and scientific communication.

Characteristics of a Living Thing

In the first biology class with either monks or undergraduates, I have slightly modified lessons with both groups of students to build to our definition of life. For the monastics, because it is a large group in a large space, I have each monk draw three living things and three non-living things (**Figure 1D**). Then, they compare answers with a partner and we draw a similar collection on the whiteboard. Though many monks have some experience with English, drawing pictures usually elicits a quicker response and quickly injects some humor into the classroom. This initial activity gets at some fundamental differences between "Western science" and the monastic texts: Is a plant a living thing? Is a mushroom a living thing? Is human hair a living thing? These basic questions immediately draw out differences between the Western understanding of life and the Tibetan Buddhist texts (**Figure 1F**). Usually there is no full agreement at the end of this discussion, but it allows us to begin characterizing what most of the "living things" have in common: grow/develop, reproduce (though not always), consume, move (though not always), etc. With this short activity, there is almost always a great energy in large room and the monks are eager to debate these topics further and learn more.

In the undergraduate classroom, we play an introductory game to build to the answer of our definition of life. First, I assemble a list of words on sticky notes and place one word on the back of each student. Then, students circulate through the class, asking each other yes or no questions to try and determine what word is on their back (**Figure 1C**). In addition to words that might come up in a first-year biology course ("mitochondria, *E. coli*"), I add words that were particularly difficult for the monastic scholars to place as living or non-living in order to spark discussion with the undergraduates once we assign these words to "living" or "non-living" categories (**Table 1**). Once everyone in the room has correctly guessed their word, together we group these words into the category of "living" or "non-living" (**Figure 1E**). While this initially seems like a trivial question to a college student, it provides an opportunity for early participation in the class and, invariably, success, which is an effective inclusive pedagogical practice (K. D. Tanner, 2013). I have used this introductory game for approximately 10 first-year classes with remarkable engagement and debate. As an undergraduate class, we then develop a list of "characteristics of living things" by looking at our table. This is where many collegiate textbooks begin as well.

In both groups, we now have our list of "characteristics of living things" and we track back to our original table of living versus non-living things to find the points of tension for clarification. For example, most monks and undergraduates will say that an apple is a non-living thing, but surely it contains cells. Also, when does a part of a living thing, such as a human hair, transition to something that is "non-living"? The question of individual living things versus a collective becomes paramount as well. How do we describe what happens when a flatworm is cut and becomes two flatworms biologically? How does this change when we understand the Buddhist view of a spirit that inhabits each living thing? These are rich subjects to mine for monks and undergraduates, with the definitions leading to excellent discussions.

After classifying the objects as "living" or "non-living" (often with a third category, "once lived") (see **Table 1**), we come to a consensus list for the characteristics of life. With some facilitation from me, the students develop a list of six to seven characteristics that are found early in an introductory biology textbook (For undergraduates, I specifically stop here and discuss viruses–we see how many of the characteristics a virus has and, depending on the consensus of the students' opinion about whether or not a virus is "alive", I try to argue in support of the opposite side using Socratic dialogue to support conceptual change (Fleming, 2018; Reich, 2003; K.; Tanner & Allen, 2005). Through a question-and-answer period, both the monks and undergraduates develop a list of these characteristics on their own (see **Figure 1E**). The monks have the dogma of their religious texts and the students the dogma of current Western science beliefs, but both can be respectfully challenged through asking questions. I facilitate the students hashing out their rules for what living things are. The conversations that arise for undergraduates are "easy" in the sense that they all have been taught the dichotomy between non-living versus living things from an early age. Being challenged early in an undergraduate career to really probing these dogmas help students appreciate the importance of interrogation. I connect this with the idea that science is a process, building theories, not laws, that should always be up for review and challenge.

Tibetan Monastic Debate and the Undergraduate Classroom

I have translated my experience with the monks to the undergraduate classroom through the use of Tibetan monastic debate to facilitate classroom scholarship. Debate is a fundamental part of the educational process in monastic

TABLE 1 | Typical table generated through class discussion to designate objects as "living" or "non-living". To develop the following table, undergraduates were each given one word that they could not see and asked to guess the word using "yes or no" questions. The difficulty of placing certain items as "living" or "non-living" allows for an introduction to biological inquisition.

Living	Once-Living	Non-Living
E. coli	Apple (no seeds)	Apple seeds
Chlamydia (obligate parasite)	Wooden Table	Metal Table
Human hair (part of)	Human hair?	Smartphone
Mitochondria (part of)	Cork	Computer (can AI become life?)
Mistletoe (parasite)	Cocoa Powder	Cloud
Monk		Fire
Yogurt (contains)		Virus?
Virus?		

communities (Vugt et al., 2020). These debates involve dozens of monks spread out in a large, open air theater, with one standing monk "educating" and a sitting monk "receiving the education" (Dreyfus, 2003; Perdue, 2014). The educating monk simultaneously does three things: takes a step, hits one hand into the other, and delivers a message to the receiving monk. Monastic debate can be used for a variety of educational purposes, including a deeper understanding of religious texts. The receiving monk listens and may or may not respond to the message, but usually do (for a sample transcript of a monastic debate, please see (Vugt et al., 2020). The educating monk may respond back to the receiving monk, but the discussion is specifically related to the particular lesson that is being delivered.

When I ask undergraduates to describe Western debates, especially in election years, they rarely have anything positive to say. The occasional student who has participated in debate teams may have more positive associations with debate, but they tend to agree that understanding and learning do not seem to be central to the "purpose" of the debate. Though many types of Western debate certainly have their merit, I would argue that, for the purpose of learning and instilling academic rigor, Tibetan style debate is really what we hope to inspire in our students. When teaching in the monastic style, I usually assign the debate in one class period and conduct the debate in the next, directing students to develop deeper understandings of the material rather than trying to pick apart opposing views. The student leading the debates are instructed to develop several main points to deliver, and the student receiving can ask clarifying questions. While I have tended to use topics that can be "debated" in the way Western students understand debate, it could be possible to use monastic debate to practice understanding biological concepts where students would use this technique to internalize these concepts.

After discussions of the debates with several monks, I have used their explanation of the purpose of debate to set up this pursuit of knowledge in the undergraduate classroom. Specifically, debates are used by the monks to probe for understanding, develop critical thinking, make connections between topics, and build compassion (Perdue, 2014; Vugt et al., 2019, 2020). Through rigorous study, monastics prepare for these debates to achieve the learning goals. When we enact debate in my courses, students choose a position to debate and present it to partners or the class (**Figure 1G**). We listen and respond to their point while taking care to focus specifically on the content. There are no winners in these debates, only knowledge gained and new perspectives considered. Teaching through the use of this style debate has allowed me to introduce potentially challenging subject manner in a way where students are not trying to win or score points. For instance, students in my introductory Synthetic Biology course have debated editing human embryos. While this subject was until recently mostly science fiction, CRISPR and other DNA editing techniques have made this work feasible. Through the use of Tibetan monastic-style debating, students have discussed the specifications to which this type of technology should be applied. In addition to this topic, I have facilitated debates on topics from "Should scientists be allowed to "create" synthetic life?" to "What type of grants should the NIH fund?". Students self-report that they found these debates engaging and enjoyed the opportunity to learn in this new way. Additionally, these debates would provide an excellent opportunity to explore how social justice issues intersect with biology, such as the ethics of informed consent and approaches to address environmental injustice stemming from racism.

Teaching With Compassion

Working with the monks has given me new appreciation for the value of compassion and led me to fully integrate it into the classroom in order to engage and empower student learning. This idea—to teach while caring—has become the cornerstone of my teaching philosophy. Specifically, I have incorporated community-building techniques into my teaching as a manifestation of this compassion. The monks live an existence that seeks out compassion in a community that reaffirms this goal. While there are times and junctures in our lives where being compassionate is difficult, if not impossible, I have made it an explicit goal of my courses to demonstrate and cultivate compassion. Though many of these instances occur naturally when I am teaching or working with students, I also intentionally add moments where we address questions of the social responsibility of biologists and consider the people involved in current and historical biological discoveries in order to build community through the discussion of challenging topics.

While it might seeem difficult to include compassion into every topic or lesson plan, finding moments to build classroom community is an effective aspect of inclusive teaching (K. D. Tanner, 2013), and compassion can lead to these moments. For example, I teach a Cancer Biology course where I build the course historically, bringing in prevalent theories from the past. We then discuss how these theories were supported or rejected. One of the characters in this history is William Halsted, who developed the radical mastectomy as an attempt to prevent the deaths of women to metastasizing breast cancer. Through the use of compassion, we can analyze the cultural context of the women who had this disease—what was the stigma around cancer at the end of the 19th century? were they empowered to make choices? what were their lives like?—and attempt to understand their feelings as they went to Halsted for the operation. Additionally, we can endeavor, though more difficult, to have compassion for Halsted, who was addicted to cocaine and by all appearances had a real desire to save lives, though his methods were truly appalling in retrospect. Teaching in this way provides multiple places where students can connect with difficult subjects, aiding in the learning process and creating classroom discussion topics that build community.

Undergraduate Interaction

In addition to the effect the monastery has had on me and my own teaching, exposure to learning in this context has also had a direct impact on a pair of my students. In 2019 I was able to bring two students to the monastery from UR through the EnCompass Program (https://international.richmond.edu/study-abroad/short-term/encompass/). This program is designed to help students access an undergraduate abroad experience who might not otherwise do so. I chose these students based on their interest in connecting with the monks, and they interacted with the monks as Teaching Assistants for our science classes there, conducted their own interviews with the monks, and continually reflected on their experience (https://blog.richmond.edu/encompassindia/). Each reported an increase in their engagement with science as a result of this experience, and this engagement has been well-characterized in these experiential learning opportunities (Daniel & Mishra, 2017; Achat-Mendes et al., 2020; Long et al., 2020). As one writes, "when I returned back to campus for classes, I found myself more engaged with my biology courses and having more personal interest in learning."

The UR students developed a strong affiliation with Buddhism and the monks, and they continued to harbor these feelings months later. One student describes his experience: "As a young American, I see clearly that many people my age naturally agonize over where they will be and what they will be doing in their future. In my view, herein lies the immense value of the EnCompass programs and others like them–they are able to provide some much-needed perspective for young people who face many paths forward in a confusing and overwhelming world. Whether I become a financial analyst, professor of philosophy, a monk or something entirely different, I believe I am able to make a more informed, comfortable, and confident decision because of my experience."

Based on the examples set by the monks, each of us built mindfulness practices that endure in our lives to this day. By experiencing the Sera Jey monastery with these students, I re-experienced my first time there and discovered connections between the monastics and our current generation of college students, including the universality of community, inquiry, and compassion.

DISCUSSION

My experience teaching and working with my monastic students is one of the most meaningful of my career. My concept of compassion has transformed from a piece to add to my courses to an organizing principle of my professional life. Working with the monks has led me to a place where I embrace and nurture the educational light inside of each of my students. Many of our undergraduate students are fueled by a sense of justice and a desire to affect change, and inspiring inquiry that is centered in compassion is a powerful way to help these students build their path forward.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

DP developed this article based on his experience in India with ETSI and at the University of Richmond.

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Dialogue-Based Learning: A Framework for Inclusive Science Education and Applied Ethics

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Dialogue-based learning is an inclusive pedagogy that leverages epistemological pluralism in the classroom to enhance cross-cultural education, encourage critical thinking across modes of inquiry, and promote novel contributions in applied ethics. The framework emerged from the Buddhism-science dialogue and our experiences teaching science courses for Tibetan Buddhists in India through the Emory-Tibet Science Initiative. Buddhism and science are two modes of inquiry that emphasize critical inquiry and empiricism, yet navigating complementarities and points of friction is challenging. Our proposed framework aims to raise awareness of onto-epistemological assumptions to convert them from obstacles into assets in dialogue. In drawing attention to epistemological orientations, our framework demonstrates that receptivity to other ways of knowing fosters clarity in one's own views while creating space for new and enriching perspectives. In this article, we contextualize the Buddhism-science dialogue, explore the development of our dialogue-based learning framework, and demonstrate its application to a novel exchange about the COVID-19 pandemic. Broader aims of the framework include increasing scientific literacy and advancing transdisciplinary research.

Keywords: science education, inclusive pedagogy, applied ethics, cross-cultural education, epistemology, Tibetan Buddhism, dialogue, scientific literacy

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INTRODUCTION

Is a jellyfish sentient? If all cells come from other cells, then where did the first cell come from? How do animals benefit when scientists experiment on them? How are mental states caused by brain states if scientists only refer to neural correlates? These are a few insights that Tibetan Buddhists raised in our classrooms in rural India as we taught science courses in the Emory-Tibet Science Initiative (ETSI). Tibetan monastic pedagogy centers on analytical debate (Perdue, 2014) and, despite having little science background, their aptitude in applying logic and discernment to newly acquired scientific concepts was humbling. ETSI encouraged us to recognize and articulate underlying onto-epistemological assumptions we carry as scientists that may not be shared by our students, and it inspired the development of a novel framework centered on epistemological pluralism as an inclusive pedagogy.

We propose dialogue-based learning as a framework for teaching science as a way of knowing by leveraging epistemological orientations to enhance diversity and inclusion, encourage critical thinking across modes of inquiry, and promote novel contributions in applied ethics. It is a two-way pedagogy, as dialogue encourages respect for modes of inquiry practiced by individuals within the classroom. Inevitably and beneficially, instructors become equal parts teacher and student.

Broader aims of the framework include increasing scientific literacy and advancing transdisciplinary research.

In this article, we contextualize the Buddhism-science dialogue, explore the development of our framework, and demonstrate its application to a novel exchange about the COVID-19 pandemic.

THE BUDDHISM-SCIENCE DIALOGUE

What's past is prologue. Contextualizing the Buddhism-science dialogue establishes why dialogue is productive in cross-cultural education. Formal encounters between Buddhism and science began in the 19th century in the context of Western imperialism, raising questions about motivations and power dynamics (Jinpa, 2010; Vörös, 2016; Sheng, 2017). For example, Darwinian theory of evolution directly challenged Biblical creationism, a tension that reverberates today. Some Western scholars sought escape from Christianity's claim to authority (Samuel, 2014) and Buddhism aligned with naturalistic explanations (Cho, 2014). At the same time, Buddhists in Asia struggled for religious independence under imperialism by positioning Buddhism as science-compatible and on equal footing with Western philosophies (Samuel, 2014).

A major shift in the Buddhism-science dialogue began in the 1980s when formal meetings between the Dalai Lama and leading scientists and philosophers were first held by the Mind & Life Institute (MLI) (Hasenkamp, 2019). MLI advanced the dialogue with its emphasis on Buddhism and science as equal partners. Collaborative research emerged in healthy qualities of mind and the effects of mental training on attention and emotion regulation (Jinpa, 2010). Francisco Varela, MLI co-founder, envisioned two broad contributions: 1) the integration of Buddhist first-person inquiry with scientific third-person inquiry; and 2) a rethinking of logic and epistemology across modes of inquiry (Hogendoorn, 2014).

In certain aspects, Varela's goals have not advanced. Buddhists and scientists frequently talk past each other, a pattern ascribed to discordant ontological assumptions (Samuel, 2014), with Euro-American onto-epistemologies dominating the dialogue (Cho, 2014). Cho argues that conflicts should also be considered from Buddhist perspectives, rather than reducing Buddhist views to objects of scientific inquiry. Buddhist concepts, Cho argues, are interpreted through Western frameworks, like karma reframed as Cartesian mind-body dualism rather than relative to its own Buddhist framework. Even agreement can end in misunderstandings. For example, Buddhism and science converge on the rejection of an independent, unitary self. But arising from onto-epistemological differences are divergences in: bases for rejection; how selfhood relates to other knowledge; and what, if any, ethical implications arise (Federman, 2011).

Two-way understanding can advance the Buddhism-science dialogue beyond the current plateau. ETSI aims to further Varela's goals by educating monastics to think critically across Buddhism and science (Desbordes & Negi, 2013). ETSI began when the Dalai Lama invited Emory University to collaborate with the Library of Tibetan Works and Archives to develop a science curriculum for Tibetan Buddhists. Since 2006, dozens of scientists, translators, staff, and over one-thousand monastics have participated in a project similar in population to a small liberal arts college. Integrating science education represents the most significant change in 600-years for the Tibetan Buddhist curriculum (Kimelman, 2018), underscoring the Dalai Lama's confidence in the promise of novel and beneficial discoveries made by scholars trained in Buddhism and science. ETSI is a historic endeavor in the early years of what the Dalai Lama calls a 100-years project (Gray et al., 2020).

For more than 150-years, Buddhism-science compatibility claims have remained consistent while the meanings of *Buddhism* and *science* have changed considerably (Lopez, 2008). To avoid this trend, we clarify that in *Buddhism* we refer to Indo-Tibetan Buddhism, also known as the Nālandā tradition (Jinpa, 2010), by virtue of it being the population involved in ETSI, but not excluding other schools. To decolonize the term, we resist using "Western science" as ground for *science*. History of science is biased toward Eurocentrism (Wallingford, 2021), and cross-cultural science education often reflects Euro-American onto-epistemologies (Sonam, 2019). Indeed, centuries before the European Scientific Revolution, Buddhists originated advanced concepts in physics (atomic theory, relativity, multiple world systems) (Jinpa & Lama, 2017), embryology (Wallingford, 2021), and microbiology (Hammerstrom, 2012). However, we also distinguish *science* from Buddhist science (Jinpa & Lama, 2017, 2020). While both emphasize critical inquiry and empiricism (Lama, 2005), significant differences in onto-epistemological perspectives exist. Further, logic in the Nālandā tradition (Rogers, 2009) differs from Western logics (Mohanty, 1992). Consequently, we define *science* in terms of ontological commitments to physicalism and a mind-independent, objective reality knowable through replicable experimentation. This contrasts with the Buddhist view that mind is indispensable for knowing itself, with claims of an objective reality mediated by mind (Cho, 2012).

DEVELOPING THE DIALOGUE-BASED LEARNING FRAMEWORK

Science is not acultural (Medin & Bang, 2014), and our framework was informed by the inextricable link between culture and the interpretation of science. Tibetan monastics are trained philosophers, and engagement naturally soared when topics highlighted onto-epistemological differences between Buddhism and science. Concepts were better understood when such differences were made explicit by emphasizing how scientists conceive and investigate reality. Our goal was not to integrate Buddhism and science, but to provide students with space for epistemological pluralism and structured opportunities to creatively reconcile ways of knowing individually. We appreciated learning Buddhist perspectives on

TABLE 1 | Goals and actions in the dialogue-based learning framework.

Goals	Actions
Cultivate an inclusive learning community	Foster a sense of belonging in the classroom (Wilson et al., 2015) and implement culturally responsive teaching (Gay, 2002)
Assess epistemological orientations in the classroom	Learn about identities and backgrounds in the classroom, acknowledge lived experiences of students (Sanger, 2020)
Create spaces for navigating complementarities and points of friction among modes of inquiry, without requiring group consensus	Use intergroup dialogue (Dessel & Rogge, 2008) to increase awareness of other ways of knowing and use dialogue as a mode of inquiry to challenge one's own preconceived notions. Focus on mutual understanding, not consensus building
Provide structured opportunities for thinking across modes of inquiry	Use Writing-to-Learn (Balgopal et al., 2012) and other pedagogies that promote reflection, synthesis, and comprehension
Leverage epistemological pluralism as a source of novel contributions in applied ethics	Explore controversies from pluralist perspectives to facilitate ethical thinking (Saunders & Rennie, 2013)

topics of mutual interest, like the origin of life and the roles of attention and perception, as these exchanges heightened our awareness of onto-epistemological assumptions in science that we had not previously recognized (see *Developing the Dialogue-Based Learning Framework* Section).

Epistemological pluralism recognizes multiple, valuable ways of knowing in a collaborative context, and integration can produce innovative transdisciplinary discoveries (Miller et al., 2008). Epistemological orientation refers to diverse beliefs within and between individuals, which is contrasted with epistemic cognition as general knowledge acquisition (McGinnis, 2016). In other words, our framework focuses on acknowledging diversity in epistemological orientations among students and instructors. We use *epistemological orientation* as an umbrella term to encompass personal epistemology, epistemological beliefs/postures/resources, and ways of knowing (Niessen et al., 2008).

In the classroom, considering epistemological orientations is an important component of learning (Hofer, 2001), and has implications for learning strategy use, comprehension, cognitive processing, and conceptual change (Hofer, 2008). Areas of interest include how individuals know, theories and beliefs about knowing, and how epistemology influences reasoning and learning (Hofer & Pintrich, 1997). Epistemological orientation operationalizes philosophical frameworks to explain how students select, extract, interpret, and abstract meaning from information (Wilkinson, 1989), and can predict how students derive meaning from instruction and learning (Wilkinson & Schwartz, 1990).

DIALOGUE-BASED LEARNING AS AN INCLUSIVE PEDAGOGY

Tibetan monastics hold positive views of science, but frequently believe that science is limited by a materialist ontology (Sonam, 2019). Many also reduced science to resultant technologies like airplanes or computers (Sonam, 2019), a phenomenon also observed among American students (Thanukos et al., 2010). To combat this trend, we explored how philosophy and science inform each other (Shraim, 2021). Leveraging epistemological pluralism created space for monastics to think like a scientist while remaining Buddhist. Monastics appreciated learning about Mendel, the 19th century monastic-scientist. Individual conceptions of who can be a scientist influences engagement (Smith and Erb 1986; Bettinger and Long 2005; Farland-Smith, 2009), positioning dialogue-based learning as an inclusive pedagogy.

We created an environment that validated and included local culture, akin to Dover's (2013) culturally responsive education. For example, we initiated conversations on mind and brain by discussing the intersection of contemplative practice and neuroscience. Likewise, we situated the scientific study of consciousness by framing questions under Buddhist theory/practice, such as *tukdam*. In *tukdam*, an adept practitioner stays in meditation after clinical death, when brain and cardio-pulmonary functions cease, and the practitioner keeps their body intact for weeks or months beyond how science defines clinical death (Zivkovic, 2014). Tapping into existing interests, students were motivated to explore how science studies biological death, from cellular to cognitive.

DIALOGUE-BASED LEARNING AS AN APPROACH TO APPLIED ETHICS

Ethical implications are central to challenges in climate change, health, artificial intelligence, and biodiversity, and diverse ways of knowing offer novel contributions to applied ethics. Ethical reasoning provided abundant openings for deep engagement in scientific methodologies. Because ethics is foundational to Buddhism (Sodargye & Yu, 2017; Kwah, 2020), students processed the curriculum through an ethical lens. Monastics wanted to know why scientific knowledge does not naturally motivate ethical action, for example, pointing to the lack of meaningful governmental responses to climate change. While scientists have rigorous processes for research ethics and integrity, and for handling scientific misconduct, science often benefits by drawing from other disciplines in applied ethics.

Ethics, spirituality, and medical practice are deeply intertwined in Buddhist culture, particularly in Tibetan medicine (Cameron & Namdul, 2020). For example, in defining life, science distinguishes between living and non-living things, while Buddhism distinguishes between sentience and non-sentience

TABLE 2 | Applying dialogue-based learning to a novel exchange between Tibetan Buddhism/Tibetan medicine and science on the COVID-19 pandemic.

Prompt	Response
What is/are the cause(s) of the COVID-19 pandemic?	**Tibetan Buddhist/Tibetan Medical perspective** Primary cause: ignorance about the misconception of an independently existing self, causing attachment to oneself and greed involving wealth and sensorial pleasure. Such unwholesome acts have detrimental effects on living species and the environment, and can lead to epidemic and natural calamities. Even though there are multiple causes of the pandemic, the primary cause of the COVID-19 pandemic is a result of immoral human behavior driven by insatiable greed **Science perspective** SARS-CoV-2, the virus that causes the disease COVID-19, likely originated from a zoonotic spillover event from contact between humans and animals. Genetic analysis indicates it originated in bats, and perhaps transmitted through an intermediate animal host before infecting humans. The virus has continued to evolve into different variants since the pandemic began
What is/are the solution(s) to the COVID-19 pandemic?	**Tibetan Buddhist/Tibetan Medical perspective** Prevention is the first step. Because the pandemic involves so many other problems, people need to deal with it not only through physical interventions such as medication but also by setting and cultivating positive mental attitudes toward this problem. From the Tibetan medical perspective, the focus is on strengthening the immune system and supporting impacted organ(s), reducing fever/infection, and balancing neuro-psychological problems. Along with taking care of the physical body, one's state of mind is critical **Science perspective** Public health interventions: outreach and education, masks, social distancing, medical treatments (monoclonal antibodies, medications), vaccine development and deployment, and social support programs. The One Health framework focuses on caring for human health and the health of all organisms, which, as a consequence, has positive effects on human health
How do you integrate the new way(s) of knowing with your existing one(s)?	**Tibetan Buddhist/Tibetan Medical perspective** Human action causes spillover events. According to Buddhism this happens partly due to confusion about the causality between such actions and transmission of viruses from animals to humans. Due to this ignorance, people unknowingly create an atmosphere where exchange of viruses occurs between different groups of animals, including humans. Attachment to oneself and thus to wealth and sensorial pleasure also plays an important role in spreading many contagious diseases. Out of attachment to profit, people keep different animals closely together in cages at marketplaces without concern for their well-being. Animals suffer from getting infected from other animals, including the primary host of the virus. As a result, humans in close contact with such animals can also get infected and suffer. In Buddhism, this is only about secondary causes and cooperating conditions relating to spillover effects or how we get viruses for which our bodies are not primary hosts. Primary causes of viruses, as discussed above, are unethical human behaviors, with little to no concern for the environment and other living species **Science perspective** Biomedical science offers mechanistic explanations for how the virus was transmitted from animals to humans, and then from human to human(s). But it does not account for the causes and conditions that instigated the human-animal interaction in patient zero, or the conditions of animals in captivity. Science has generated vaccines and other medical interventions to prevent and treat illness. Scientists predict the pandemic will end when we achieve global vaccine uptake and/or reach natural herd immunity. Clinical research in mind-body health has studied many aspects of how state of mind influences health and recovery from injury and illness. But public health programs have largely not emphasized these findings, especially the role of preventative and integrative medicine. Disease has been the focus rather than improving overall global health. Investments are needed for monitoring viruses that can potentially infect humans, and for studying risk factors for future spillover events

(Balgopal et al., 2021). The Buddhist view naturally includes ethical consequences, as sentience implies the capacity to suffer and promotes non-anthropocentric solidarity with other organisms (Kwah, 2020). Buddhism is based on a moral-spiritual understanding of causality, inextricably uniting ethics and causality (Sodargye & Yu, 2017). Axiological commitments in science (value-*free*) and Buddhism (value-*full*) mediate their respective views (Kwah, 2020), exerting broad influence on how knowledge is acquired, organized, and applied. Thus, opening the classroom to epistemological pluralism can lead to novel advances by connecting science with ethical inquiry.

APPLYING THE DIALOGUE-BASED LEARNING FRAMEWORK

Insufficiency in scientific literacy contributes to global challenges, as anti-science movements influence public discourse on conservation, vaccination, distribution of research funds, and climate change (Thanukos et al., 2010). When science is perceived as non-threatening to and co-existing with other ways of knowing, it creates opportunities for transdisciplinary research, which is increasingly understood as necessary for solving complex global challenges (McBean and Martinelli, 2017). We propose dialogue-based learning as a framework (**Table 1**) for inclusive science education and applied ethics. The first two steps work together; the instructor designs an inclusive classroom and raises awareness of epistemological orientations. Similarly, steps three and four are complementary; the instructor creates space for navigating modes of inquiry and provides structured opportunities for thinking across them. The fifth step leverages epistemological pluralism to generate novel contributions to applied ethics. In a typical STEM course, this framework can include and utilize epistemologies from other fields (e.g., social sciences, humanities) and from lived experiences (e.g., spiritual, cultural).

As an illustrative example (**Table 2**), we applied the framework in a dialogue, among authors, on the COVID-19 pandemic. Díaz-Almeyda, a biologist, provided the science perspective, while Geshe Lhundup, a senior Tibetan monastic, provided the Buddhist perspective, and Namdul, an anthropologist and Tibetan medical doctor, provided the Tibetan medical perspective. Authors were asked to explain their views for a general audience. Then, after reviewing the other authors' explanations, each author presented an adjusted view based on what they learned in the dialogue. We present a significantly condensed summary of how authors explained the causes of and solutions to the pandemic, and how they revised perspectives at the conclusion of the dialogue. In concordance with the framework, there was no expectation to arrive at consensus or reconcile differences.

DISCUSSION

In our example dialogue, raising awareness of other modes of inquiry prompted all authors to revise their perspectives. In addressing the causes of the pandemic, the Tibetan view focused primarily on human behavior, while the science view focused on biological mechanisms. For solutions, the Tibetan view emphasized personal action and preventative medicine, while the science view relied on public health interventions and medical treatments. Interestingly, both the Tibetan and science perspectives adapted in response to the dialogue. The Tibetan view added mechanistic explanations from the science view as concrete examples to illustrate behavioral consequences. The science view reflected on the earlier emphasis on biological mechanisms and added preventative and integrative medicine as solutions.

Both perspectives borrowed ideas from the other in ways that highlighted individual strengths while expanding into new areas. It is fascinating to note that neither perspective needed to give up any central aspect of their original views. Rather, by emphasizing epistemological pluralism, the dialogue guided authors to consider other perspectives and relate new understanding with their expertise. In this way, dialogue-based learning is a pedagogical enhancement strategy, and is scalable because original course content is preserved.

Our dialogue-based learning framework was inspired by experiences teaching in ETSI. Leveraging epistemological pluralism in the classroom enhances learning by increasing diversity and inclusion, and by creating opportunities for novel contributions in applied ethics. Broader aims include increasing scientific literacy and advancing transdisciplinary research, crucial factors in solving today's global challenges. All classrooms are epistemologically plural; recognizing this in dialogue facilitates deep understanding of and respect for many ways of knowing.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

MR, ED-A, TN, and YL contributed to the conception, development and revision of the manuscript. All authors contributed to and approved the submitted version.

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Mixed-Method Evaluation of the Public Health Questionnaire for Estimating Depression Among Tibetan Buddhist Monastics

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Background: Depression is the largest source of global medical disability, highlighting the importance of translating and validating depression screening instruments to improve our understanding of differences in the prevalence of depression in divergent cultures around the world. The aim of this study was to translate and evaluate a widely used depression screening and diagnostic instrument, the Patient Health Questionnaire-9 (PHQ-9), for use with Tibetan populations. A secondary aim was to use the Tibetan-PHQ-9 (T-PHQ-9) to estimate the prevalence of depression symptoms in a population of Tibetan-speaking Buddhist monastic scholars engaging in a 6-year science curriculum in India, the Emory Tibet Science Initiative (ETSI).

Methods: Three-hundred-eighty-four monastics (363 monks, 21 nuns) completed the T-PHQ-9. We computed measures of internal consistency and conducted factor analysis to evaluate scale performance. Following this, we evaluated the prevalence of depressive symptoms among the monastic population. We also conducted cognitive interviews with six monastics to explore their thought processes when completing the instrument and when thinking about depression symptoms.

Results: The T-PHQ-9 had acceptable reliability and demonstrated a single-factor structure. While having low energy was the most commonly endorsed symptom, monastics did not have overall higher endorsement rates of other somatic symptoms when compared with endorsement rates of emotional symptoms. Over 10% of the monastics scored in the moderately severe to severe range and met criteria for major depressive disorder using standard diagnostic criteria cut-offs. First year monks had the highest mean score, and there was not a significant difference between monks and nuns.

Abbreviations: ETSI, Emory-Tibet Science Initiative; MDD, Major Depressive Disorder; PHQ-9, Patient Health Questionnaire-9; T-PHQ-9, Tibetan Patient Health Questionnaire-9.

Cognitive interviews revealed some variation in the cognitive processes used to complete the instrument, particularly with symptoms related to energy and concentration.

Conclusion: These preliminary findings indicate that the Tibetan PHQ-9 is a reliable instrument for assessing depressive symptoms, as evidenced by its ability to inform how symptoms are experienced, interpreted, and communicated among Buddhist monastics. Results from the cognitive interviews may be important for further refining the instrument.

Keywords: depression, patient health questionnaire-9, Tbetan, Buddhist, monastic, translation, cross-cultural psychiatry

BACKGROUND

Over 350 million people worldwide suffer from depression, making it the most common mental health disorder and the largest contributor to global disability (Smith, 2014; Vos et al., 2017; James et al., 2018; Salleh, 2018). Typified by persistent sadness and a lack of interest or pleasure in previously rewarding activities, the causes of depression are multifactorial, just as its effects can be both wide-ranging and long lasting. Given this global impact and burden of suffering, it is critical to understand cross-cultural variance in depressive symptoms, as well as the factors that influence these symptoms across time and place. Vital to this understanding is the development of screening and diagnostic instruments adapted and validated for use among diverse populations.

An estimated 150,000 Tibetan refugees live in exile, having left Tibet due to political and cultural oppression[1]. Previous work has documented elevated levels of trauma, post-traumatic stress disorder, and anxiety among these Tibetan humanitarian migrants (Mills et al., 2005; Evans et al., 2008). The Tibetan diaspora began in 1959 with the escape of the 14th Dalai Lama to India to avoid persecution by the Chinese People's Liberation Army (Conway, 1975). While Tibetan refugees still travel to Dharamsala - the current residence of the Dalai Lama in India - the number has dropped over the last decade, due in part to economic and cultural uncertainty in India (Purohit, 2019). Many Tibetans from both Tibet and India are traveling to other countries, particularly Canada, Switzerland, the United States, and Germany (Purohit, 2019). With this history of persecution and oppression and elevated risk for mental health concerns, and given the dynamic insecurities experienced by Tibetans living in diaspora communities, it is crucial to translate, adapt, and evaluate psychometric instruments for screening depression among Tibetans and Tibetans in exile.

Among the almost 40,000 Tibetan Buddhist monastics living in India and nearby countries (Sonam, 2019), a growing number participate in a novel science curriculum, the Emory-Tibet Science Initiative (ETSI). First created in 2006 at the behest of His Holiness the Dalai Lama, ETSI is a collaboration between Emory University and the Library of Tibetan Works and Archives to establish a bidirectional convergence of science and spirituality. The program aims to innovate and implement a comprehensive and rigorous educational curriculum built on shared systems of knowledge to teach contemporary scientific knowledge to Tibetan monks and nuns. International science faculty collaborate with Tibetan translators and teachers to provide continuous English-Tibetan translation during classes. As of 2018, over 1,500 monastics have engaged with what is now a 6-year ETSI science curriculum in neuroscience, biology, physics, and epistemology, which includes a summer science intensive program (Gray and Eisen, 2019). Beginning in 2018, scientific concepts taught during ETSI are now included in the examination for the Geshe Lharam degree, the monastic equivalent to a western doctorate. For several reasons, the ETSI program is a salutary venue for the process of translating a depression questionnaire into Tibetan. First, Tibetan interpreters have been essential to ETSI throughout the project, and the process and theory of translating scientific concepts into Tibetan has been foundational to every part of ETSI (Gray et al., 2020). Translators and monastics alike are extraordinarily adept at the iterative and dynamic process of cross-cultural and cross-linguistic scientific dialogue. Second, monks and nuns enrolled in ETSI are highly educated in Buddhist logic, philosophy, and models of mind, making them thoughtful reporters of the phenomenology of mental health symptoms (Gray and Eisen, 2019).

In addition to the importance of constructing tools for evaluating depression symptoms in Tibetan communities, exploring depressive symptoms among Tibetan Buddhist monastics presents an opportunity to understand the proximate outcome of the complex interaction of factors that enact both risk for, and buffering against, depression. On the one hand, growing research highlights the deleterious impact to mental health that can result from becoming a humanitarian migrant (Fazel et al., 2005; Chen et al., 2017). On the other hand, many monastics maintain a lifestyle that may buffer them from developing depression. For example, the interconnected community of a monastery likely reduces loneliness and economic stress, both of which increase the risk for mental illness during post-migration resettlement (Laban et al., 2008; Chen et al., 2017). Monastics often primarily consume a vegetarian diet, which has been associated with a reduced prevalence of depression (Jin et al., 2019). Moreover, some - though not all - Tibetan Buddhist monastics maintain regular contemplative practices, which have positive effects on mental health and well-being (Verma and Araya, 2010). In addition to contemplative practices, Buddhist belief systems may buffer

[1]127935 Tibetans living outside Tibet: Tibetan survey. Hindustan Times Dec 04, 2010

monastics from the harmful effects of stress or trauma, and may provide a mental framework that shapes symptoms of depression and mental distress (Holtz, 1998; Hussain and Bhushan, 2013; Lewis, 2013; 2018). In sum, the lived experience of monastics likely includes both risk and buffering factors, and examining mental health and illness in this context will enrich our overall understanding.

In this study, our first aim was to translate one of the most widely used depression diagnostic and screening instruments (Tam et al., 2019), the Patient Health Questionnaire (PHQ), for use with Tibetan populations. The PHQ-9 depression diagnostic instrument is a well-validated measure for detecting depression and reflects current criteria for major depression (Kroenke et al., 2010; Blackwell and McDermott, 2014), but to our knowledge it has not been translated for use with Tibetan populations. Our second aim was to evaluate the Tibetan PHQ-9 (T-PHQ-9) using quantitative (factor analysis and psychometric evaluation) and qualitative (cognitive interviewing) methods. A final exploratory aim was to use the T-PHQ-9 to estimate the prevalence of depressive symptoms in a population of Tibetan-speaking Buddhist monks and nuns enrolled in ETSI.

METHODS

Overview: The Emory University Institutional Review Board approved the study, and all work was conducted in accordance with the Declaration of Helsinki. As described in more detail below, we first created a Tibetan translation of the widely used depression screening and diagnostic instrument, the Patient Health Questionnaire (PHQ). Next, we administered the T-PHQ-9 to participating monks and nuns during implementation of the summer curriculum in 2019. Finally, we conducted cognitive interviews with a separate group of monks (n = 6) to examine the cognitive processes involved in completing the T-PHQ-9. For the quantitative portion of the study, we obtained signed, informed consent from 453 monastic participants (419 monks, 34 nuns) after a full description (in Tibetan) of study procedures, risks, and potential benefits prior to conducting any study procedures. For the cognitive interviews, we obtained informed consent from six monks after a full description (in Tibetan) of study procedures, risks, and benefits.

Participants: Participants in the quantitative study were Tibetan monastics from five monasteries and four nunneries in India who attend classes to study science with the Emory-Tibet Science Initiative (ETSI), held at the Science Center at the Drepung Losel Ling Monastery in South India. We recruited monastics via an optional face-to-face presentation. There were no exclusion criteria. Because we were interested in item performance, we omitted participants who failed to complete all T-PHQ-9 items (n = 69) and thus the final dataset was composed of 384 monastics (363 monks, 21 nuns). Participants in the cognitive interviewing component of the study were six monks enrolled in ETSI and in residence at Emory University.

Measure: The Patient Health Questionnaire depression module (PHQ-9) is a measure of depression severity that scores each of nine Diagnostic and Statistical Manual of Mental Disorders (DSM 5) symptom criteria according to how often the symptom bothered the person during the previous 2 weeks: 0 = “not at all”; 1 = “several days”; 2 = “more than half the days”; 3 = “nearly every day” (Kroenke et al., 2001). The nine symptoms assessed are: anhedonia, depressed mood, insomnia or hypersomnia, fatigue or loss of energy, appetite disturbances, guilt, diminished ability to think or concentrate, psychomotor agitation, and suicidal ideation. A 10th item rates how the depression symptoms impact daily function, but it is not used in scoring and is not included here. We used conventional categories of symptom severity: 0–4 = Minimal depression severity; 5–9 = Mild; 10–14 = Moderate; 15–19 = Moderately severe; 20–27 = Severe. In addition, we used the conventional cut-off score of 10 or more for major depressive disorder (MDD); (Kroenke et al., 2001).

Measure translation: In the first phase, one translator proficient in English and Tibetan translated the PHQ-9 into Tibetan. Translation and back translation of the Tibetan version of the PHQ-9 was repeated by a group of five translators who provided feedback on the original version until they believed that the Tibetan version accurately corresponded with the English version.

Prior to administering the survey, the research coordinator explained the purpose of the study through an experienced English to Tibetan interpreter employed as an educator by ETSI. After consent, monastics completed the survey with no time restrictions, and they were able to ask questions of the research team via the translator.

Statistical Analysis: All data were double entered to ensure accuracy. To address our first aim of evaluating individual T-PHQ-9 items and scale performance, we examined the internal consistency by computing the Cronbach’s alpha coefficient. To evaluate construct validity, we conducted a factor analysis to evaluate whether a single factor model could be generated for the nine items of the Tibetan PHQ-9, as has been reported in previous studies (e.g., Cameron et al., 2008; Liu et al., 2011; Kocalevent et al., 2013; Dadfar et al., 2018), or whether a two- or three-factor model was a better fit. First, we assessed whether the data were suitable for conducting a factor analysis and found that it was appropriate to proceed using Bartlett’s test of sphericity [$p < 0.001$] (Bartlett, 1954; Hair, 2009), and the Kaiser-Meyer-Olkin measure of sample adequacy = 0.83 (Kaiser, 1960; Hair, 2009). Next, we conducted a principal component analysis, excluding cases listwise.

To describe the prevalence of depressive symptoms in the monastic population, we generated descriptive statistics (mean, standard deviation, and endorsement frequency) for single items and the median and interquartile range for the sum score of the measure. In addition, we describe monastic participants’ scores according to PHQ-9 diagnostic categories, separated by year in the ETSI program and sex for comparison. We also calculated the prevalence of depression with 95% confidence interval, using the cut-off score of 10 for MDD. To examine whether depression scores differed by ETSI year, we conducted one-way ANOVA followed by Games-Howell post-hoc multiple comparisons tests. To examine whether scores differed between monks and nuns, we

TABLE 1 | T-PHQ-9 descriptive, reliability, and factor loading statistics.

	Mean	Std. Deviation	Corrected item-total correlation	Alpha if item deleted	Factor-pattern coefficient
Anhedonia	0.43	0.70	0.39	0.69	0.56
Depressed mood	0.36	0.65	0.45	0.68	0.62
Sleep problems	0.55	0.85	0.43	0.68	0.60
Low energy	0.87	0.80	0.40	0.69	0.57
Appetite change	0.38	0.69	0.35	0.70	0.51
Low self-esteem	0.70	0.90	0.42	0.68	0.58
Concentration difficulties	0.66	0.88	0.34	0.70	0.49
Psychomotor agitation or retardation	0.42	0.73	0.46	0.68	0.63
Suicidal ideation	0.06	0.37	0.30	0.71	0.45

conducted a Mann-Whitney test. All statistical analyses were conducted using SPSS (version 26.0 for Windows, **SPSS**, Inc., Chicago, IL).

Cognitive Interviews: To explore the cross-cultural equivalence of the T-PHQ-9 and to learn about the cognitive processes involved in comprehension of and response to each survey item, we conducted cognitive interviews with six monastic scholars enrolled in ETSI and in residence at Emory. Cognitive interviewing (CI) is a method commonly used to understand how survey items are understood and answered, and it can help identify problems in item translation and interpretation as well as in survey design, organization, and instruction (Collins, 2003; Beatty and Willis, 2007; Campanelli et al., 2015; Meadows, 2021). In general and in practice for the current study, CI involves the administration of survey items, interspersed with the collection of additional information about the accompanying response to each item.

Two researchers (W.K., M.W.) and the translator (T.S.) conducted the cognitive interviews via Zoom using the following procedure. First, we provided the monk with the T-PHQ-9. Next, the translator read each item. After the interviewer read each item, the interviewer asked the monk a series of four questions. First, they asked the participant to describe what the item means in their own words. Next, they asked them to describe their thought process if they were to answer the question. The interviewer used probing prompts to elicit more detail, including asking the monks to describe a situation in which someone might feel or experience the symptom or to think of an example in which someone might experience the symptom. Third, they asked the participant if they know anyone experiencing this symptom. Finally, they asked the participant how they think people would feel saying they experience the symptom. After asking these four questions about each of the 9 T-PHQ-9 items, the interviewer asked the participants two final questions: "What do you think is missing from this questionnaire that would be helpful to evaluate depression?" and "Can you think of any idioms, sayings, phrases, or expressions that you or others use to refer to depression?"

RESULTS

Reliability and item analysis: Cronbach's alpha for the total scale was 0.71, which is considered acceptable. The mean scores for all T- PHQ-9 items are shown in **Table 1**. All items, if deleted, would decrease the total alpha, although the alpha would be essentially the same if item 9 (suicidal ideation) was deleted. Item nine also had the lowest item-total correlation and was endorsed far less frequently than all other items (see **Table 2**). Item-total correlations ranged from 0.30 to 0.46 (**Table 1**).

Construct validity: A principal components factor analysis yielded a single-factor structure, which accounted for 31.1% of the variance in item responses and yielded a total eigenvalue of 2.80. The factor-pattern coefficients ranged from 0.45–0.63 (**Table 1**).

Prevalence of symptoms and participant characteristics: Item response frequencies are detailed in **Table 2** and visualized in **Figure 1**. The majority of monastics chose "not at all" for all items except "low energy", for which the majority (43.5%) chose "several days". T-PHQ-9 sum scores are detailed in **Table 3**.

Participant sum scores were non-normally distributed, with skewness of 1.08 (S.E. = 0.13) and kurtosis of 1.14 (S.E. 0.25). The mean sum score for all monastics was 4.43 (Std. Dev. = 3.70). First year monks had the highest mean score (M = 5.99, SD = 3.44), which was significantly higher than the mean score for other years (F (6, 377) = 5.34, $p < 0.001$). Post-hoc analyses using Games-Howell tests indicated that first year monks reported higher levels of depression than monks in their fourth ($p = 0.001$), fifth ($p < 0.001$), and sixth ($p = 0.001$) years. There was not a significant difference between the monks and nuns (U = 3,185, $p = 0.20$). Using diagnostic criteria from previous reports, 244 (58.3%) monastics were in the minimal severity range (0–4), 119 (31.0%) in the mild severity range (5–9), 34 (8.90%) in the moderate severity range (10–14), 6 (1.60%) in the moderately severe range (15–19), and 1 (0.30%) in the severe range (20–27) (**Table 3**). The prevalence of MDD based on the traditional cutoff score of 10 was 10.7% (95% CI 7.77, 14.2).

Cognitive Interviews: Overall, the monks tended to indicate that they were thinking of specific examples or contextual factors in their efforts to answer each of the items. For example, with respect to answering item 3 ("Trouble falling or staying asleep, or sleeping too much?"), one monk stated, "So, this could happen when one is occupied by some important things perhaps an important task that one had to-one has to finish . . . because of which, you know, one is not able to sleep . . . this could also happen when one has too much stress or pressure and with the

TABLE 2 | T-PHQ-9 item responses listed as percent monastics endorsing each response option. Each of the items is scored with the following 4-point response options: 0 (not at all), 1 (several days), 2 (more than half the days), and 3 (nearly every day).

	0	1	2	3
	"Not at all"	**"Several days"**	**"More than half the days"**	**"Nearly every day"**
Anhedonia	68.0	22.7	8.1	1.3
Depressed mood	71.9	20.8	6.3	1.0
Sleep problems	64.6	20.3	10.9	4.2
Low energy	36.5	43.5	16.9	3.1
Appetite change	71.6	20.6	5.7	2.1
Low self-esteem	54.7	26.0	14.1	5.2
Concentration difficulties	55.2	29.2	9.9	5.7
Psychomotor agitation	70.3	19.5	8.1	2.1
Suicidal ideation	97.1	0.8	1.0	1.0
Mean (Std. Dev.)	65.5 (15.5)	22.6 (10.5)	9.00 (4.43)	2.86 (1.69)

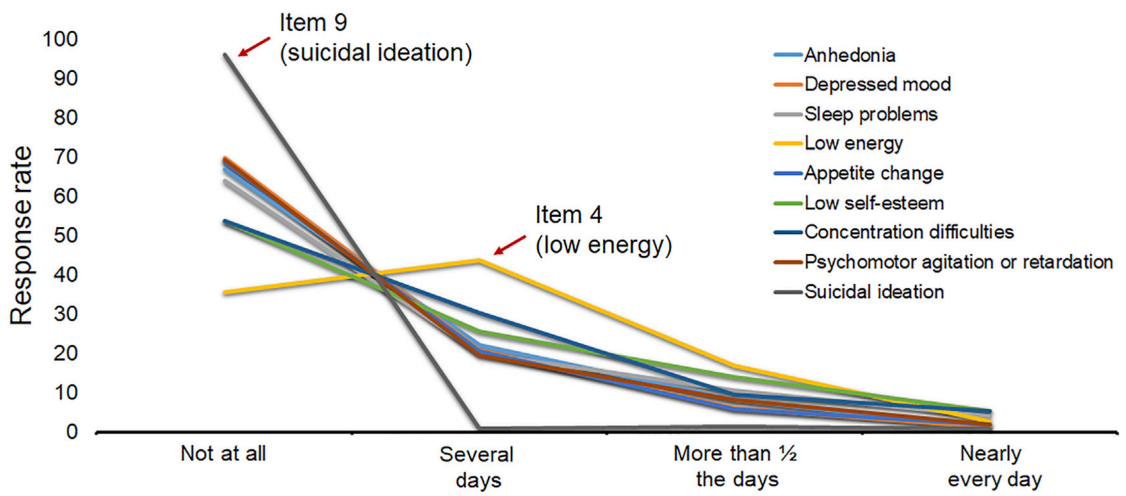

FIGURE 1 | T-PHQ-9 item responses visualized as percent monastics endorsing each response option.

TABLE 3 | Mean, standard deviation, median, interquartile range (IQR) of T-PHQ-9 sum scores, as well as frequency (number and percentage) of monastics falling within each of the diagnostic categories. All scores are reported 1) according to monastic year for monks, 2) for nuns, 3) for all monks, and 4) for all monastics combined (monks and nuns).

	1st year	2nd year	3rd year	4th year	5th year	6th year	Nuns	All monks	All
	(N = 97)	**(N = 38)**	**(N = 52)**	**(N = 52)**	**(N = 64)**	**(N = 60)**	**(N = 21)**	**(N = 363)**	**(N = 384)**
Mean (std dev.)	5.99 (3.44)	4.32 (3.95)	4.90 (4.20)	3.56 (3.11)	3.30 (3.04)	3.65 (3.46)	4.05 (4.64)	4.45 (3.64)	4.43 (3.70)
Median	6.00	3.00	4.00	3.00	2.00	3.00	2.00	4.00	4.00
IQR	6.00	6.25	5.00	4.00	4.00	4.00	6.00	4.00	4.00
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Minimal, 0–4	36 (37.1)	23 (60.5)	28 (53.8)	37 (65.4)	47 (73.4)	41 (68.3)	15 (71.4)	209 (57.6)	224 (58.3)
Mild, 5–9	46 (47.4)	9 (23.7)	18 (34.6)	16 (30.8)	13 (20.3)	15 (25.0)	2 (9.50)	117 (32.2)	119 (31.0)
Moderate, 10–14	14 (14.4)	5 (13.2)	4 (7.70)	1 (1.90)	3 (4.70)	4 (6.20)	3 (14.3)	31 (8.50)	34 (8.90)
Mod. severe, 15–19	1 (1.00)	1 (2.60)	1 (1.90)	1 (1.90)	1 (1.60)	0	1 (4.80)	5 (1.40)	6 (1.60)
Severe, 20–27	0	0	1 (1.90)	0	0	0	0	1 (0.30)	1 (0.30)

excessive sleep one is not able to you know wake up uh or stay awake even if one has to finish a task." In answering item 5 ("Feeling bad about yourself—or that you are a failure or have let yourself or your family down?"), one monk noted, "So this question is not very clear to my mind, I would be thinking about things that I couldn't achieve. Mmm, and I would also be thinking about the time when I left Tibet . . . that action, or my decision to leave Tibet could have repercussions for my family, especially my immediate families. So I would be, you know, I'd be thinking about those."

It was common for monks to have difficulty thinking of a person they know who experienced a given symptom. For example, the majority (4) of the monks reported that they could not think of anyone they know who has experienced feeling like a failure or having low self-esteem (item 5). However, for other symptoms, monks were able to call to mind someone they know who has experienced that symptom. For example, with reference to sleep difficulty (item 3), one monk stated, "I could think of one monk from my monastery, you know, who was-who was very old, and he had so much trouble, you know, sleeping, difficulty in falling asleep. And it might be because of his health or because of his age. He would often, you know, cry all throughout the night, so I know of that person."

The interviewees' ability to think of someone they know who experienced each symptom may be related to the degree of stigma surrounding the disclosure of each of the depressive symptoms. There were several symptoms that the monks felt would carry stigma and for which people might feel embarrassed to discuss, particularly eating too much (4 monks noted that people would feel embarrassed to admit this) and thoughts of suicide (all the monks indicated that people may feel uncomfortable sharing thoughts of suicide). Half of the monastics reported that people might feel uncomfortable disclosing that they have trouble concentrating on their studies. One monk explained an inherent tension involved in answering the questionnaire: "So [I] think it will be-people may struggle depending on their, you know, their outlook. For instance, the monastics are encouraged to, you know, speak truth and be honest. So, you know, even if you are not-feeling even if you are feeling hopeless and, you know, feeling down, you might be tempted to answer in the opposite but, you know, that ethically that will be wrong. So, there would be this tension. On the other hand, you know, people might feel a little embarrassed or uncomfortable, you know, revealing that they are feeling down or hopeless."

The cognitive interviews also revealed that there appear to be differences in the ways in which monks interpreted the items than are generally intended for the PHQ-9. For example, with respect to item four about low energy, two of the monks noted the distinction between mental and physical energy, and reported that this distinction would be important for answering the item. Several monks appeared to reflect on item 6 ("Trouble concentrating on things, such as reading the newspaper or watching television?") with reference to *interest* level, rather than as a general difficulty with concentration. For example, one monk noted, ". . .this to me seems to be asking about one's interest or related to one's interest. So, for me, . . . I'm interested in reading and I'm also interested in watching . . . I would think about, you know, where my interest lies and so on." Similarly, other monks discussed situations in which they have difficulty concentrating on something that does not interest them. When asked if they know anyone experiencing this symptom, most monks talked about classmates or friends who are bored by a particular topic or activity. For example, one monk stated, "Uh yes, my classmates, you know, when we were young, and we were made to read books, you know, they would be completely bored and couldn't focus. And similarly, you know, watching-when we were made to watch documentary shows, we couldn't- or they couldn't concentrate." Only one of the monks referenced difficulty concentrating due to mood: "So, this could happen because one is not well, or that one is feeling unhappy. Or that something else is occupying, you know, the person's mind, such as work or tasks that one has to finish."

With respect to what they thought is missing from the survey, half of the monks mentioned the relationship between stress and depression. For example, one monk stated, "You know, depression and other mental problems, such as, you know, mental health such as, you know, stress . . . often, these two, tend to have many similar symptoms. And as such, you know, it's a little hard for [me] to kind of distinguish between the two." A second stated, "Uh well [I] think that depression could be initiated or started by feeling too much pressure. And so, therefore, it could be started by one's custom or culture or habits. So, perhaps questions about these might be helpful."

DISCUSSION

Here, we examined a Tibetan translation of the PHQ-9, which will be important for screening and understanding the prevalence of depression symptoms among Tibetans and Tibetan refugees faced with dynamic globalization and economic and cultural insecurity. The PHQ-9 reflects current criteria for major depression and has been translated into various languages, but to our knowledge, this is the first translation into Tibetan. The quantitative data collected from monastics enrolled in ETSI indicate that the T-PHQ-9 has acceptable reliability and holds promise as a clinical instrument. Our exploratory factor analysis indicates that the T-PHQ-9 has a single factor structure, as is consistent with many previous studies (Cameron et al., 2008; Liu et al., 2011; Kocalevent et al., 2013; Dadfar et al., 2018). While other studies have supported a two-factor model, corresponding to somatic (e.g., sleep, appetite, and fatigue items) and non-somatic or affective symptoms (e.g., mood, suicidal thought items) (Krause et al., 2010; Elhai et al., 2012; Petersen et al., 2015; Guo et al., 2017), our data do not support such a model. Although the T-PHQ-9 demonstrates acceptable reliability, it has a lower alpha than has been found in other studies, many of which have yielded alpha levels above 0.80 (e.g., Kroenke et al., 2001; Cameron et al., 2008; Liu et al., 2011; Wang et al., 2014; Rancans et al., 2018; Kim and Lee, 2019). The lower reliability may reflect something about the current translation, or it may reflect true differences in the way that symptoms are interpreted, experienced, or reported by this unique study population.

With respect to individual item performance, these data indicate that all items were important to the overall construct. However, there was variance in item endorsement. Consistent with other studies, very few monastics endorsed experiencing suicidal ideation (Huang et al., 2006). The most commonly endorsed item, on the other hand, was "Low energy", and the majority of the monastics (>60%) reported experiencing this symptom at least several days per week. Several studies conducted among Asian populations have found higher rates of somatic symptoms (sleep problems, low energy, and appetite change) [for example, (Kleinman and Kleinman, 1985; Yen et al., 2000; Huang et al., 2006; Lotrakul et al., 2008)]. While the monastics in this study had relatively higher rates of endorsement of "Low energy", they did not have higher rates of other somatic symptoms compared with endorsement rates of emotional symptoms (e.g., anhedonia). Taken with the single-factor model identified with these data, this study is not consistent with the characterization of Asian racial/ethnic groups as more likely to experience somatic symptoms of depression and it highlights the importance of moving beyond simple east-west essentialism (Kirmayer, 2001; Boiger et al., 2018).

While the PHQ-9 is among the most widely used measures of depression and has proven important as a diagnostic and screening tool in disparate clinical contexts and among diverse populations, the diagnostic utility of the current translation will require further evaluation. Previous research has indicated that diagnostic cutoff scores of 10 are clinically meaningful and have high levels of sensitivity (88%) and specificity (88%), as individuals with major depression seldom score below that range (Kroenke et al., 2001; Kroenke et al., 2010). We used this conventional diagnostic scoring criteria to interpret the current data; however, future research should examine the diagnostic validity of the T-PHQ-9. Responses in the current study indicate that 89.3% of monastics fall in the minimal and mild range for depression. Interestingly over 10% of the monastics fell in the moderate and above range, with 2% categorized as experiencing moderately severe or severe depression.

Rates of MDD in the current sample are lower than those reported in other refugee and exiled populations. For example, the PHQ-9 was used to detect MDD in 44% of Syrian asylum seekers in Greece (Poole et al., 2018), in 27% of Syrian refugees in Germany (Borho et al., 2020), and in 50% of a heterogeneous population of refugees living in refugee housing in Sweden (Leiler et al., 2019). Among Tibetan adolescents and young adults living in India, 79% scored above the cut-off score of 1.75 on the Hopkins Symptom Checklist-25, indicating significant emotional distress (Evans et al., 2008). Interestingly, that study found that rates of distress were higher among young adults born in Tibet who escaped to India, compared to ethnic Tibetans born in exile. Monastics in our sample were a mix of monks and nuns born in Tibet and those of both Tibetan and Indian descent born in India; unfortunately, we did not collect birth or migration histories from the monastics in our study and are unable to examine whether the same trend was observed. Regardless, rates observed in our study were much lower than prevalence rates observed in the study of adolescents, consistent with the overall indication that monastics have lower rates of depression symptoms than other comparable refugee populations. Moreover, while clinical interpretations of these data warrant great caution, our preliminary findings indicate that the T-PHQ-9 is sensitive to variation in depression symptoms and that it appears to be operating similarly to other population studies that evaluate the point prevalence of depression.

Monastic scholars in our sample are not only refugees but are also students, and careful consideration should be given to determining the most appropriate comparison groups to interpret the current data. These monastic science students may have relatively more in common with other student populations than with a more general adult population or with other refugee populations, especially to the Geshe Lharam degree is considered equivalent in rigor to the PhD and likely carries comparable levels of effort and stress, Among studies of students, there appears to be a relatively large amount of variance in PHQ-9 scores and in the prevalence of MDD. For example, in a study of Chinese medical students, the mean PHQ-9 score was 6.02, with 13.5% of respondents reporting scores that reflect MDD (Sobowale et al., 2014). Similarly, a large study of South Korean medical students found that 13.7% of students scored in the moderate to severe range (Yoon et al., 2014) and rates of MDD among medical students in India were found to be over 30% (Patil et al., 2018). A study of medical students in Cameroon found that 30.6% scored in the moderate to severe range (Ngasa et al., 2017). There also appears to be extensive variation in prevalence of depression among university students, with rates of depression ranging from 10 to 85% (Ibrahim et al., 2013). A recent meta-analysis indicates that depression is highly prevalent among PhD students, with a pooled prevalence of clinically significant depression of 24% (Satinsky et al., 2021). Depression levels in the current study were at the bottom-end of what is generally seen in studies of university and post-graduate students.

Taken together, the prevalence of depression symptoms among these monastic scholars is similar to rates found in general populations, but quite a bit lower than is often found in both refugee and student populations. Monastics may experience lifestyle factors or engage in health behaviors that are protective from depression, a possibility that warrants further inquiry. Several large studies point to factors that exert direct effects on risk of major depression, including income, sleep disorders, and chronic diseases (Majidi et al., 2018). Other studies find associations between nutritional status, adiposity, and physical activity and rates of depression (Ngasa et al., 2017; Li et al., 2018; Jin et al., 2019). A large body of research has found that education (Bauldry, 2015; Madden, 2016) and religiosity (Wangmo and Teaster, 2010; Gearing and Alonzo, 2018) are protective against depression, which would suggest that monastics may be relatively buffered from experiencing depression. However, another study of Tibetan refugees living in India found lower prevalence of depression and importantly found no association between monastic status or educational variables and depression levels (Sachs et al., 2008). Future research should examine the relationship between depression symptoms and specific health behaviors among monastic refugees.

However, the findings from this study indicate that the monastic scholars are not free from depression; rather, rates are higher than are found in several population studies (for example, (Kocalevent et al., 2013; Brody et al., 2018)). Monastics in our sample may experience specific burdens that affect their experience of depression symptoms. Tibetan culture and traditions, including the growth and development of monastic universities serve the purpose of maintaining Tibetan culture in the hope of a future repatriation to the ancestral homeland. A community in diaspora navigates the present circumstance with great care. By definition, the aspirations of the community are to return, but the reality requires the laying down of a local foundation. As the years pass, all that may be known is the current reality, and the more settled in place, the weaker the claim becomes for repatriation. Diaspora communities risk adverse mental health as a consequence of state impermanence (Benedict et al., 2009). Previous studies have found high rates of trauma exposure, post-traumatic stress disorder, and depressive and anxiety symptoms among children and adolescent Tibetan refugees (Servan-Schreiber et al., 1998; Evans et al., 2008), findings that are congruent with our own and which highlight the importance of mental health resources for exiled communities. Moreover, during the cognitive interviews several monastics reported on the high rates of stress and pressure involved in their monastic studies, and pointed to this stress as a risk factor for depression.

Although the quantitative data indicated that the T-PHQ-9 is a reliable instrument for quantifying depression symptoms, the cognitive interviews suggest that monks may interpret some items differently than is generally intended by the PHQ-9. This was especially the case for the concentration and low energy items, in which Tibetan Buddhist cultural and linguistic distinctions between interest/concentration and mental/physical energy may be crucial. This knowledge may be used to refine the T-PHQ-9 for future use. Importantly, researchers have identified two disparate objectives of cognitive interviewing in the context of survey development (Willis, 2015; Meadows, 2021). On the one hand, CI can be reparative, with a primary goal of identifying and fixing specific problems in the survey. Alternatively, CI can be used descriptively to gain a better understanding of whether and how the survey is tapping into the construct it is intended to measure. Here, we conceptualized and analyzed our interviews as more aligned with the latter goal. However, we only surveyed the monastics in residence at Emory and thus may not have reached saturation in our dataset. Moreover, these interviews could be used in an iterative way to refine and optimize the T-PHQ-9, an important next step for future research. In addition, the discrepancies in meaning for interest/concentration and mental/physical energy may have influenced the factor analysis. More fine-grained examination of these cultural-linguistic distinctions will be important toward more definitively interpreting the one-factor result and for ruling out a two-factor model that may have arisen with a more precise or concordant translation for those items. Gaining clarity on item 4 (low energy/fatigue) will be particularly crucial since it falls on the somatic factor in two-factor models. Two of the monks noted the distinction between mental and physical energy when thinking about this item and had difficulty answering as a result. A thorough comparison of the cultural/linguistic meaning and cognitive scripts involved in answering this item would help disambiguate the possible interpretations. Moreover, it is possible that the monastics would be more sensitively assessed if that item were split into two items, tapping into mental *and* physical energy as distinct symptoms.

Limitations and future directions: For several reasons, caution is warranted with diagnostic claims or interpretations of the current data. First, as stated above, we did not conduct any validity estimates within the current study. Future research should examine convergent validity of the T-PHQ-9 and other validated instruments. In addition, we did not conduct clinical diagnostic interviews, and we are unable to determine whether the cut-off score of 10 for MDD that we used is applicable for this study population. Second, while we conducted cognitive interviews with a small number of monks, more thorough qualitative evaluations are warranted to explore how monastics understood and related to the translated items given the complex ways that linguistic and cultural differences will impact how emotions are perceived and interpreted, as well as how distress and symptoms of distress are communicated (Kirmayer, 2001). Related, the monastics are relatively unfamiliar with survey instruments like the PHQ, which may influence the way they thought about the items or answered the survey. In fact, one monk pointed this out in the cognitive interview. This may help explain why a relatively high percentage (15%) of the monastics who took the T-PHQ-9 left at least one of the nine items unanswered. In addition, while we have placed our findings alongside a large body of research examining the prevalence of depression using the PHQ-9, the uniqueness of the population studied here limits the generalizability of the current preliminary results to other Tibetan-speaking populations. The T-PHQ-9 should be evaluated among other populations, an extension of the present research that would help overcome potential translation difficulties and help inform the interpretation of the data presented here.

Another important next step in this research is to examine how age and sex impact monastic depression symptoms. While we did not find a significant difference between monks and nuns, we were likely underpowered to examine whether well-described sex-differences in depression (Evans et al., 2008; Brody et al., 2018; Eid et al., 2019) are also evident among this monastic population. Nuns are newly involved with ETSI, and as their representation grows there will be more nuns available to participate in future iterations of this research program. It will also be critical to examine lifestyle risk factors as well as social and cultural influences on monastics' experience of depression symptoms. Finally, this study raises critical issues related to the ethical obligations and best practices in conducting cross-cultural research at the intersection of mental health.

CONCLUSION

Preliminary evidence indicates that the T-PHQ-9 is a reliable instrument for future analyses. While we must interpret these data with care, they highlight the importance of diagnostic and clinical resources made available to monastics.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Emory University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JM helped design the study, analyzed and interpreted the data, and was a major contributor in writing the manuscript; DS helped design the study, helped administer surveys and enter data, and helped with data interpretation and writing the manuscript; WK and MW conducted and transcribed the cognitive interviews; EB helped analyze the cognitive interviews; TS translated the survey, helped administer surveys, and helped with data interpretation and writing the manuscript; HC helped enter data and helped with writing the manuscript, CR contributed to interpretation of the data and writing the manuscript, JZ and AE were major contributors in designing the study and helped with interpretation and writing the manuscript. All authors critically read and approved the final manuscript.

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Translation: A Key Component of a Hundred-Year Project

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The Emory-Tibet Science Initiative (ETSI) has embarked on a historic endeavor of introducing a systematic and sustainable science education program within the traditional Tibetan monastic institutions. His Holiness the Dalai Lama, who conceived and supports this initiative, calls it a hundred-year project. From the very beginning, translation from English to Tibetan has been an integral part of this project because of the need to prepare course materials as well as to facilitate on-site classes and lab activities in the Tibetan language. Our translation process involves not just conveying novel and foreign concepts across cultures but doing so with a scientific language peppered with technical terms that are not readily representable in the target language. In addition to the linguistic barriers, cultural and technical ones further complicate the process of communication. A case in point is the concept of life, or correlation versus causation, or the view that consciousness is an emergent property of the brain, where each construct has its corresponding but differing concept in Tibetan Buddhism. When engaging with such existing parallel yet divergent terms or concepts, the translators must strike a delicate balance and avoid forsaking the distinctive characteristics and connotations involved. In this article, the ETSI translation team shares its journey—highlighting the needs felt, challenges faced, and solutions sought. We discuss the translation principles guiding our work and the handling of such scientific features as graphs, acronyms, units, chemical names, and formulas. We hope our work will inspire other similar projects around the globe and encourage them to continue bridging barriers to cross-cultural dialogues, promoting cross-fertilization of knowledge for human flourishing.

Keywords: Dalai Lama, ETSI, science translation, buddhist monastics, science and buddhism, Emory-Tibet science initiative

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INTRODUCTION

The Emory-Tibet Science Initiative (ETSI) is a unique educational project conceived and supported by His Holiness the Dalai Lama, and formally launched in 2008 by Emory University in collaboration with the Library of Tibetan Works and Archives (LTWA), India. An ambitious endeavor anticipated to endure the next hundred years, ETSI has already journeyed through its first three phases of planning, piloting, and implementing systematic and sustainable curriculum to provide modern science education within the Tibetan monastic institutions in India (ETSI, 2019). In 2019, ETSI graduated its first cohort of monastic students—a total of 233 monks from nine monastic academic institutions—who had completed the six-year science curriculum. ETSI has entered the "sustainability" phase focusing on training select groups of monastics in science pedagogy and research methodology to assist participating monastic institutions in building an indigenous pool of science teachers and researchers.

In its current form, ETSI focuses its efforts on the scientific disciplines of physics (with some introductory lessons in mathematics and related components), life sciences, neuroscience, and philosophy of science. Studies have shown that "learning academic courses through a foreign language medium may pose conceptual, linguistic and psychological problems" (Sabri et al., 2005). Moreover, since the monastics enter the program with little to no prior knowledge of English language, translation and interpretation of science instructions in Tibetan language has been an integral part of the program from its inception (Gray et al., 2020).

Historical Perspective

Where does this put ETSI historically in terms of translating modern scientific terminology and concepts into Tibetan? To our knowledge, there had never been a systematic and coordinated effort invested in this direction, at least not at an institutional or state level before 1959, the year when the Chinese Communists invaded and occupied Tibet (Tsering and Gyatso, 2000). Individuals had undertaken sporadic attempts ('Jam dpal chos kyi bstan 'dzin 'phrin las, 2013; Chophel, 2014 and Lopez, 2018), but no documentation of any organized and systematic efforts are to be found. Under the new regime in Tibet, science textbooks written in Tibetan were gradually implemented into curricula, at least at the primary and middle school levels. Such materials primarily addressed topics in general science, life sciences, physics, and chemistry (Ljongs Zhing-lnga'i mnyam bsgrigs, 2006).

ETSI acquired some of these limited classroom materials and has consulted them as references in the program's initial years. However, one prominent gap was the absence of any material in Tibetan on neuroscience. Thus, ETSI's work in neuroscience had to start virtually from ground zero, and to build on a meager basis for the other disciplines. Ironically, among the equally important and relevant fields of science engaged by the program, neuroscience seems to be the one that most readily deals with topics with the greatest potential to foster interdisciplinary discussions and exchanges to which senior monastics would already have much to contribute. Also, considering the program's aspiration to rally contemplative traditions and modern science to promote positive human values towards sustainable global peace and human flourishing, the approach of contemporary neuroscience to the question of consciousness in general, and compassion, empathy, attention, etc. in particular, bring the discipline centerstage. These reasons prompt us to focus this paper on our efforts to translate neuroscience concepts and terminology in capturing the dynamics of our work.

In retrospect, Tibet and Tibetan civilization undertook a major transplantation of Buddhism from India that lasted several centuries before rooting itself deeply into Tibetan culture and flourished locally. The importation of Buddhism started not long after the current written form of Classical Tibetan Language, together with its grammatical rules, was created and introduced during the reign of Tibet's 33rd King, Songtsen Gampo (c. 557–649 AD). The mission was spearheaded by Thonmi Sambhota, who invented the script based on Indian Devanagari scripts after intensive studies in India. Interestingly, around the 8th century, the above enterprise of translating Buddhist canons received royal patronage, which resulted not only in the commissioning of individual translation projects, but also in the founding of general principles and rules governing translation and standardization (*Sgra-sbyor bam-gnyis*)[1]. These general principles and rules of translation have proven immensely helpful to us. In addition, we use Tibetan medical texts to generate possible ideas and suggestions to render neuroscientific terms and concepts into Tibetan. However, references to brain anatomy in Tibetan Buddhist canons and indigenous writings are tellingly rare (The Dalai Lama, 2017). Even in Tibetan medical texts, neurology is not addressed as a separate area of study. Instead, all references to brain-related concerns are interspersed throughout the chapters in connection with different body systems, pathologies, and treatment (Bdud-rtsi snying-po, 2011). Early on, ETSI team became aware of how differences underpinning cultures, worldviews, concepts, approaches, and systems of classification heavily affected defining a discipline and identifying its components as well as the relationships among them. As a result, ETSI translators were even more wary of borrowing existing Tibetan medical terms and concepts to map them onto a corresponding area in neuroscience, for doing so could potentially hamper doing justice to the purpose and integrity of translation and instead create more misunderstanding, albeit inadvertently.

Translation: Challenges Faced and Methods Adopted

The work of translating neuroscience materials into Tibetan began from scratch and it involved employing the entire spectrum of translation methods and tools available to the team, which we share here with our readers. First, whenever possible, we aimed for simple direct translations such as in "*Dkar-rdzas*"[2] for white matter and "*Skya-rdzas*" for gray matter, where we provided a word-for-word substitution in the same order (Wylie, 1959). Second, when such an orderly arrangement did not fit in the target language, the same word-to-word substitution was pursued with the word order adjusted. For example, "*Mdun-gnos klad-shun dkyil-gyi steng-cha*" for

[1]Sgra-sbyor bam-gnyis. Toh 4347, Dege Tengyur, vol. co (sna-tshogs) page 131b -160B. This is a ninth-century lexicon containing specific rules and methods for translating Sanskrit texts into Tibetan and it is accompanied with a full-length glossary of Buddhist terms translated into Tibetan from Sanskrit. Publisher/ Printery: Delhi Karmapae Chodhey, Gyalwae Sungrab Partun Khang; Delhi. 1985.

[2]The transliterations provided in this paper are based on the Wylie system developed initially by Turrell Wylie in 1959 and later extended by a team at the Tibetan and Himalayan Library, co-directed by Nathaniel Garson and David Germano, in a manuscript draft entitled, "THL Extended Wylie Transliteration Scheme", which can be accessed at https://www.thlib.org/reference/transliteration/ #!essay=/thl/ewts.

"ventral medial prefrontal cortex" and "*Mthong-tshor gyi bar-rim klad-shun*" for "secondary visual cortex" are where a direct restoration from the translations would leave us with "prefrontal cortex medial ventral" and "visual secondary cortex", respectively. Sometimes, adding a tag in the translation was called for in the target language when performing a simple direct translation. For example, "*Kham-tsig klad-zho*" for "amygdala," is where the rear tag "*klad-zho*", *meaning* "*brain substance*", helps put it in the context of brain science. Otherwise, just leaving it as "*Kham-tsig*," which translates to "almond," its Latin root, could create confusion.

Third, the next option would be to try indirect translation when a simple direct treatment may be impossible or simply not the best option. This method could include several approaches within it. For example, we translated "cell" to "*Phra-phung*" which literally means "tiny body" or "tiny structure." If we had instead settled for "*Shag-khung*," which is what the original term conveys, a "small quarter," that might turn out to be an unwise choice, prone to creating unnecessary confusion. Once a term is established, we again return to simple direct translation wherever applicable and possible. This is reflected, for example, in the translation of "nerve cell" and "brain cell" respectively into "*Dbang-rtsa phra-phung*" and "*Klad-pa'i phra-phung*" where word-for-word treatment and the same word order are pertinent. Connected with these terms is "neuron" which is translated as "*Dbang-rtsa phra-gzugs*," a rather wordy choice, but the translation conveys the context along with a reference to a tiny structure through the use of a different word than the one for "cell". These examples illustrate how the team works to retain synonyms in translation, rather than merely lump synonyms from the source language into a single translation in the target language for the sake of expediency. Of particular interest might be how we translated "cell body" as "*Phra-phung-lus*", not as "*Phra-phung gi lus*" which would be "cell's body or body of a cell", and that is of course not the meaning intended in the source term. Generally, a three syllabled word like "*Phra-phung-lus*" is a rare occurrence in Tibetan.[3] We mostly prefer pairing up the syllables. It is also what most of Tibetan linguists would recommend achieving in general writing to avoid leaping over the proper point of break and thus leading to misrepresentation, both in communication as well as in comprehension.

Fourth, sometimes, we use different yet contextually sensitive Tibetan terms for a single scientific word. For example, "nucleus" is translated as "*Lte-rdhul*" meaning "core particle" for the nucleus of an atom, and "*Lte-nying*" meaning "core-essence" for the nucleus of cells, and "*Tshom-bu*" meaning "bundle" for structures like the cochlear nucleus. Likewise, in instances such as the phases of mitosis, we have found it more practical for the purpose of student learning and teaching, to convey the phases with terms that capture the distinctive salient features of each, rather than in strict adherence to the original names. For example, "*Stug-ngo*", for "prophase", captures the feature of "thickening" of the chromosomes during this phase. Similarly, in connection to the anatomical direction and reference planes of the brain, we did not examine the actual origin of the terms used in the source language. Instead, we settled on using the existing Tibetan terms for spatial orientation and appropriate additions to accurately pinpoint the areas of focus (Eisen, 2012).

Phonetization is another area of interest in any translation project of our scope. A reliable and accurate, albeit a slightly sophisticated, system of phonetization combined with transliteration for Sanskrit terms into Tibetan already existed (Sgra-sbyor bam-gnyis, 1985). This phonetization system was painstakingly developed by our predecessors primarily to retain the purity of tantric mantras, both in sound and meaning. However, this system would be applicable only if the source terms being phonetized and transliterated were already in established Sanskrit or Hindi spellings, or at least in spellings or sounds sharing the same parallel linguistic dynamics as those languages. With English as the source language from which to translate, the above method was not an option for our project. Precisely because of this vacuum regarding a uniformly applicable standard Tibetan phonetization system for languages including English and Chinese, a few loosely defined schools or styles in the Tibetan community exist to represent terms from other languages. A few of these "schools" take a more conformist stand whereby the original sound of the term may be compromised in favor of a more Tibetanized sound or even recognizable Tibetan way of spelling for a foreign name (Ljongs Zhing-lnga'i mnyam bsgrigs, 2006). Yet another school sticks to the term's original sound even if it means settling for a non-Tibetan sound, let alone a non-Tibetan way of spelling the sound. The ETSI translators have opted to stand by this latter style, although without a formal consensus and written rule. Therefore, proper nouns such as Darwin and Mendel would be found as "*Dar-win*" and "*Men-del*" respectively in the ETSI textbooks, not as "*Tar-win*" and "*Dhar-win*" or "*Men-tel*" and "*Men-dhel*", reflective of the other practices. One way of telling the difference in style is to identify whether letter-symbols outside of Tibetan alphabet are used in a text.

Furthermore, not every scientific term is deemed easily translatable or worth the effort in favor of convenience and conveyance. This category includes acronyms such as DNA, RNA, mRNA, etc. The ETSI practice has been to phoneticize these acronyms using the same criteria as above. However, there is a sub-section in this group of acronyms that are better received if expanded in translation rather than just retained in phonetics in Tibetan usage. This relates to acronyms such as MRI, fMRI, EEG, SNRI, etc. which would become too cumbersome and unclear if phoneticized, or at minimum would require tagging with a clue after the phoneticized rendition to hint at the meaning at the cost of residual inconvenience. Associated with this challenge are certain terms such as "lysin" "lysis," or "lysing" where there is

[3]This is an example of loan translation approach. Although it may initially sound strange to a Tibetan ear, it conveys the meaning of the source word clearly and also indicates a foreign source (Heim and Tymowski, 2006).

TABLE 1 | Science textbooks and other bilingual educational materials produced by ETSI to date.

S.No	Subject	Count
1	Primers: bilingual science textbooks specifically designed and developed	20
2	Supplementary Science Books—bilingual	2
3	English-Tibetan Modern Science Dictionary	1
4	Video Lectures: in-class bilingual videos filmed at the locations	403
5	Distance Learning Videos: bilingual modules on various scientific topics	112
5	ETSI Webinar Recordings	33
7	Presentation Slides: bilingual slides used as teaching and learning tools	7,768
8	Standardized Scientific Terms in Tibetan	6,300

almost no other option but to resort to phonetics. In doing so, it would be preferable to use a non-Tibetan spelling to give the impression of its being a foreign term at the first sight. That means rendering "lysin" and "lysis" as "*Lee-sin*" and "*Lee-sis*" respectively in Tibetan to convey the substance and the biological process of lysing. In this case, the original sound is retained as conveyed in a non-Tibetan spelling reflected in the double slants on top, represented here by "ee." By extension, "lysing," as a verb for a biological process, is rendered as "*Lee-bshig thebs-pa*" or "*Lee-bshig gtong-wa*," with a portion of the phonetics attached to a Tibetan action word, suggestive of the action of either undergoing or causing to undergo lysis (Eisen A., 2018).

Subtle differentiations in scientific concepts such as speed versus velocity, or among power, force, and energy also present a challenge for translation. One option is to coin completely novel allocations, but such neologisms may take too long to be utilized fully. Besides, there already are terms in the Tibetan language that express the general concepts of the words listed in each of the above groups, so efforts to coin new, unfamiliar terms might be superfluous as well as counterproductive. In such situations, we have chosen a different approach of arbitrarily allocating existing synonyms with specific meanings, such as "*Mgyogs-tshad*" for speed and "*Myur-tshad*" for velocity, to represent the nuanced notions within the general concept as has been done in English (Hewitt and Samphel, 2010). We hope that overtime these renditions will acquire the specific meanings associated in that context.

Another, formidable challenge for translation is words that represent familiar concepts or notions commonly found in any culture, or discipline around the world. Thus, no one would expect or imagine having to struggle with learning about, say mind, health, life, safety, etc. through totally new and unfamiliar terms. However, there may be very subtle, yet significant differences in the meaning of those words among cultures or disciplines. The ETSI team has its own set of such word groups to tackle and does its best in negotiating the usage in translation. Among these words are "life," "living," "consciousness," and "awareness". Superficially, the words already have their presumed equivalents in the target language and are thus ready to be employed correspondingly. Yet the existing meanings of the words in the two traditions tend to create tension in the actual usage. The ETSI team continues to use the same familiar terms but warns students of the difference in subtleties during lessons and continues with the narration expecting the terms to be understood from the perspective of their respective traditions. Interestingly, in the context of consciousness, awareness, and the like, one may assume that Buddhism must cover a wide range almost accounting for every imaginable category and have corresponding terms ready. The ETSI team has found that is not always the case. Among all the diverse ways of classifying mental phenomena, Buddhism does not seem to categorize mental phenomena into emotions and cognitions. Hence, it does not have existing terms that distinguish these two broad categories. Textual sources refer to distinguishing features that characterize the categories while explicating and articulating them, but never employ a discrete term for the type. Unsurprisingly, several propositions for formulating these distinctions in Tibetan have emerged in writings or discussions, particularly concerning "emotions" (Khabdha, 2019). However, we invented our own, "*Sems-myong*," literally translating to "mental experience" or "mental feeling" (Mascaro et al., 2017). "*Sems-myong*" was chosen over the older terms proposed by others because they already had existing overlapping meanings. The same situation arose for translating the word "cognition." Although we are not completely satisfied with our usage of "*Nges-'dzin*" as a translation for cognition, we think it is a close translation, but we remain open to better versions.

As the monastic students graduate to the next class every year and with the number of technical terms in translation growing both in volume and usage, the need for a reference material where one can locate words easily and revisit to understand context and meaning is acutely felt. We recently achieved this long-awaited goal of compiling a glossary. In addition, we have published 20 primers for the disciplines covered in ETSI, plus a couple of supplementary books (**Table 1**).

In translating technical terms, we follow not only guidelines set forth by the great Tibetan translators of the past, but also contemporary practices such as accepting loan-word (*lezer* for laser) and providing loan translation (*Phra phung lus* for cell body) that are practiced widely in many fields (Heim and Tymowski, 2006). However, the method of bringing loan-words into Tibetan as currently practiced by us or other science translators based in India or Tibet is phonetic borrowing rather than transliteration since we don't have a unified standard system of transliterating English to Tibetan—something that the Tibetan translators must develop.

Standardization Process

We follow a stringent process for standardizing terms to be adopted and used in printed materials. Suggestions for translations of new technical terms encountered and initially refined during informal work by individual translators are welcome from any corner. However, before any word is officially adopted and entered into published works, it must be tabled for discussion and deliberation at the annual translation conference. Experts in different fields of Tibetan studies such as medicine, astrology, Buddhism, poetry, history, and literature are invited to these conferences together with the resident translators of the ETSI and representatives from the LTWA. Conferees deliberate on the new terms and concepts from the different scientific disciplines together with the proposed Tibetan translations. Often, Western experts in the respective fields are also in attendance to shed light on the subtleties and nuances of the terms and concepts. Thus far, 12 annual conferences have been held since 2009, each lasting about a week on average. To date, we have adopted a total of 6,300 new Tibetan terms through this process. As noted earlier, words finalized during these conferences are open to improvement when better choices are formulated and tabled for subsequent meetings and consensus reached. One clear example is the term for "action potential", the Tibetan translation for which underwent a few adjustments before adoption of the current form, "*Las-'jug nus-pa*" (Eisen et al., 2016). Besides, each final draft translation of a textbook is cross-checked by fellow translators and then sent for vetting, at least for the early textbooks, by Geshe Lhakdor, Director of LTWA.

CONCLUSION

We are proud to share that our work is impacting our community significantly, particularly within the Tibetan monastic communities and the educated laity. It imports concepts new to the culture and offers corresponding linguistic tools so that the Tibetan language communities can discuss on topics of practical relevance such as science and technology, inventions and innovations, collaboration between science and Buddhism (*Khabdha*, 2009–21)[4]. This clearly shows how ETSI is introducing new knowledge and insights into modern science as well as contributing to the vocabulary of Tibetan language to reflect these new frontiers of knowledge. Moreover, and more importantly, these efforts are making a significant contribution in facilitating interdisciplinary discussions as well as encouraging critical, comparative, and analytical writings such as *An Anthology of Scientific Knowledge*, *Ten Reasons Why Monastics Should Study Science*, *Being Emotional about "Emotions"* (*Khabdha*, 2009–21)[4], all works of the monastics trained through ETSI or related programs. Such encouraging advances suggest that ETSI is well poised to realize the vision of His Holiness the Dalai Lama to — "(bring) together the best of the Western and Tibetan Buddhist intellectual traditions for their mutual enrichment and for the discovery of new knowledge" (ETSI website, 2021).

Moving forward, we remain committed to and passionate about that shared vision. We will continue our efforts in science translation and vocabulary building; and through that effort, hope to become an effective force for invigorating the ETSI's current new phase of generating new cohorts of monastic research partners and indigenous science teachers. This next phase will undoubtedly make a significant contribution towards making the monastic science education robust, sustainable and productive long term.

We hope our work will inspire other projects of cross-cultural nature around the globe and encourage others to continue overcome barriers to inter-disciplinary and cross-cultural dialogues. We are interested to see this happen particularly in the fields of modern science and compassion, thereby promoting "mutual enrichment" of the participating cultures and leading to "the discovery of new knowledge" conducive to human flourishing.

[4]Khabdha.org is an online platform for Tibet related news, announcements, and discussions. Browse their website https://www.khabdha.org for modern science related articles, discussions and book announcements. Particularly, search by typing in Tibetan script "tshan rig" for articles and book announcements between 2009 - 2021.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Self, Free Will and Compassion: Shared Constructs in Neuroscience and Buddhism

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The authors, a neuroscientist and a Buddhist monastic who met through the Emory Tibet Science Initiative, highlight similarities in the understanding of mental activities found in both traditions. An important principle discovered is the parallel processing of multiple mental activities, which reveals the existence of a unitary self and free will as illusions. These insights provide the rationale in Buddhism to develop a culture of compassion. Meanwhile western psychology and neuroscience have found brain circuits that have evolved to support social and even altruistic behaviors, giving compassion a physical basis in our brains as well. These insights then set the stage for a shared interest in an altruistic compassionate society.

Keywords: subconscious, body, compassion, skandhas, free will, brain, meditation, altruism

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INTRODUCTION

The authors (DJ, LG) met each other through the Emory Tibet Science Initiative (ETSI) programs first in 2009 in Dharamsala, and later at Mundgod, India. From the beginning, ETSI was a bidirectional relationship—western scientists learn about Buddhist principles as much as Buddhist monastics learn about western science. DJ remembers fondly evening podium discussions in Dharamsala after full days of teaching neuroscience to very attentive students. In these session, senior Tibetan monastics asked questions about science, and scientists asked questions about Buddhist principles. In many cases answering these questions came down to trying to better define what we each mean by "mind," "self," and "consciousness," and the concept of "causality" underlying it all. LG became interested in Science reading the Mind and Life dialogues "Sleeping, Dreaming and Dying," (Varela, 1997) "Consciousness at the crossroad," (Houshmand et al., 1999) where His Holiness the Dalai *Lama* had mutually fruitful discussions with some of the prominent scientists in the field on topics such as memory, emotions, states of consciousness, death, etc. He was fascinated by the interesting findings of modern science about how our memory forms, how lesions in some parts of the brain lead to altered cognitive and behavioral processes.

What we realized over time is that in many aspects Buddhist and Scientific thinking converges on similar key insights—though with different background philosophies and terminology. In this short perspective article we are presenting some aspects of these shared insights. We note that the aim is not to present final truths, but to contribute to an ongoing discussion with the hope to increase mindfulness—and ultimately compassion.

THE MIND AS MULTIPLE PARALLEL PROCESSES

DJ: Neuroscientists by and large these days are materialists in the sense that to them the mind originates with neural activity. Therefore, there can be no mind and no mental activity without a so-called "neural correlate." This neural correlate is then conceived as a complex activation pattern of neural networks in the brain that through their activity code "represent" mental activity. Thousands of studies have been published on the activity and function of these underlying neural networks, and quite a few principles of operation have been determined. For example, we now know that neurons communicate through electrical impulses called action potentials, and that each neuron receives on the order of ~1,000 inputs from other neurons through connections known as synapses that require the passing of a chemical messenger for transmission to occur (Kandel et al., 2021). Additionally, through input-dependent biochemical modulation of proteins in our neurons, the signaling properties in our neural networks are adapted on the timescale of seconds, minutes, and hours. Processes such as sleep, emotions, excitement, and importantly memory formation all depend on both electrical signaling as well as biochemical modulatory processes. We have also learned that neural networks are not homogenous but composed structurally of distinct functional subsystems such as thalamus, cerebellum, basal ganglia, and cerebral cortex, that each have distinct and complex arrangements of different cell types with highly specific connectivity.

The overall neural correlate of mental activity then involves a parallel activation of all these subsystems, each dedicated to specific aspects of the computational tasks at hand, such as evaluating sensory inputs, memory retrieval, eliciting emotions, decision making, and motor control of our limbs. We can now through a technique called optogenetics in experimental studies mostly carried out in mice transiently inactivate or activate each of these subsystems and determine their contribution to the overall network function and behavior. Remarkably, between mice and men (and everything in between), the identity of these functional subsystems and their internal architecture and dynamical properties is largely preserved, though of course involve different overall brain sizes and numbers of neurons. From another angle then, the same networks that are studied though optogenetics in mice, can also be examined with techniques of cognitive psychology and fMRI imaging in humans. The conclusions are much the same—many brain structures carry out dedicated pieces of the overall computational task underlying the processing of our mental content. Importantly, the brain does not wait for external input to start processing, rather it can act as a simulation engine anticipating the results of one's actions in the world (Buzsaki, 2019), and playing through alternative scenarios of such actions before choosing one.

LG: According to Buddhism, each and every moment of the so called psycho-somatic entity is not a single unit, but consists of five separable but interconnected aggregates, called skandhas: the material form (rupa skandha), the feeling (vedana–affective aspect of the experience, such as pleasant, unpleasant or neutral) associated with it, the perception/recognition (samña–identifying raw sensory data with the help of concept or labels, such as when one tastes a food and recognizes it as a sweet, sour, salty etc.), the mental formations (samskara–reactive or purposeful aspect of mind) and consciousness (vigyana–the cognitive aspect of the experience). Insight on these skhandas is gained when one contemplates how mind and body interact to give rise to different experiences, and one reflects on the changing nature of consciousness. Carefully observing the conditioned and dependent nature of these five skandhas both on external and internal factors, one further notices their interactions. This conditional interrelationship creates the world of experience, with consciousness being responsible for subjective awareness.

DJ and LG: Comparing the neuroscience and Buddhist perspectives we realize that we both understand the mind as a set of conscious and subconscious component processes that operate in parallel. By not understanding the subconscious processes and their causal influences over our thoughts we are bound to their influences without seeing them. In Buddhism, mindfulness meditation is a practice of bringing one's attention on the momentary nature of mental phenomena, and can be used to raise awareness of subconscious processes. In neuroscience the identification of neural networks subserving specific subconscious functions leads to their better understanding.

THE ILLUSION OF A UNITARY SELF AND FREE WILL

DJ: A neuroscientist looking at activation patterns of the neural networks of the brain may not expect a "self" emerging from the distributed parallel processing taking place. So where does our mental sense of "self" come from? One aspect to consider is that in terms of evolution our brain exists in order to optimize survival of the body. Our brain activity centers around planning actions and judging the consequences of actions (Buzsaki, 2019), all of which involve moving our body. Hence our body acts as an agent that affects change in the environment and in turn is affected by it. Tracking the state and possible motion of the body is therefore central to the processing function of our neural networks, and reflected in many sub-networks. We have only one body through space and time. Our memory of past actions using this body is embedded in our neural networks, as are future expectations of what it might do and where it will be. These processes provide an important aspect in the formation of "self" as a single unique entity.

For humans specifically, the self is also a concept on which we can reflect using language. A special frontal cortical network of the left hemisphere then has taken on the function of an "interpreter" as defined by Michael Gazzaniga (Gazzaniga, 2011). The input from other neural networks as received by this interpreter then fills our conscious perception of "self," and our perceived reasons for acting. Importantly, such reasons and actual causes of actions can arise from many different subsystems, and be executed before the "interpreter" becomes even aware of such reasons. For example, my lab studies how the basal ganglia will nudge the brain to commit actions that bring us immediate rewards, such as a sweet. Subconscious neural networks like the basal ganglia have evolved to be fast and efficient in guiding vital decisions such as fight or flight, or food intake. In contrast, the deliberate system of our cortex that can guide decisions based on associative processes and deliberations involving memory and cognitive goals is much slower (Kahneman, 2011).

How does the presence of multiple parallel brain processes involved in decision making impact our concept of "free will"? One thing we are certain of is that brain activity involves chaotic dynamics, meaning that infinitesimal small differences in brain state at one time can lead to large differences in brain state soon afterwards. For this reason alone, human behavior and decision making will remain unpredictable at the level of individual decisions. In addition there is evidence that individual synaptic transmission events between neurons in the brain are stochastic, and therefore neural processing at the finest scale is inherently random. So in which sense may our "Will" be "Free" then? Operationally what we may mean by "Free" is that we can pick choices that are not immediately bounded by some brain process, but encompass considering our entire past experience in making decisions. Hence, if freedom involves taking into consideration as many factors and prior experiences (such as our moral education) as possible, our cortex needs to take control, and make sure that decisions are made after sufficient deliberation. These deliberations of choosing actions are instantiated by underlying multiple parallel neural processes that are in part chaotic, and in part random as described above—hence ultimately the conscious impression that our decisions are freely willed by a unitary self is an illusion.

LG: Buddhist philosophy holds that due to ignorance, the five aggregates are experienced as an independent, single, unified self. One of the five aggregates, the mental formation (samskara), which is the reactive aspect of mind and acts like a magnet drawn towards a metal, plays an important role. The so-called "I" does not have a will free from any cause or condition, and there is no single unified self. Upon examining the perceptual process, which is a central aspect in mindfulness meditation, the perceptual process leads to thoughts (vitarka), which in turn trigger conceptual proliferation (prapancha). This conceptual proliferation creates a deeply embedded net of thoughts, projections and associations, leaving strong karmic imprints, which in turn, along with the current appraisal of the situation, determine how we make a decision. All these processes happen at lightning speed, which creates this illusionary sense of unified, independent "I," and this illusion inevitably creates attachment towards "I," and fear concerning this "I," which becomes the root cause of our suffering. The strong habitual blind reaction to different stimuli is thought to be happening on a subconscious level. As the Buddha himself said: "Avidya (ignorance) is various types of unawareness such as the perception of these very 6 dhatus (basic elements) as unitary, as a whole, as permanent, as stable, as enduring, as source of happiness, as "self," as "I," as "mine" etc." (the Buddha, Salistamba Sutra, Reat, 1993). In the words of Chandrakirti, 7th century Buddhist master of Prasangika school: "First, one grasps for "I." Then one clings to the objects as "mine." I bow to the one that gets compassionate towards beings that helplessly turn the water-wheel of samsara as such" (Trisoglio, 2003). Through mindfulness meditation, by examining clearly these five aspects of the notion of "I," the dissection of the subjective personality into its constituent parts clears the misleading assumption that an independent, freely willing, unchanging agent "I" is behind our every experience. This analysis leads to insight into the ultimately selfless (anatma) nature of our existence, to the truth that all the constituent parts of our psycho-somatic entity are ever-changing, and that there is no "I" apart from these five aggregates, nor any of the five aggregates is "I." This insight leads to the realization that the self is nothing but a construct conceptually designated on the interaction of interrelated but separable systems within our psycho-somatic entity. We can find a reflection of this realization in statements on the nature of mindful observation by noted scholars: "Through meditation, mindful observation of our own experience and its ever-changing nature can lead to more balanced, equanimous management of emotions, without blind reactions to stimuli, thus creating a mental gap between stimulus and response" (Brown et al., 2007). Or as stated by Krishnamurti (1980), "In observation one begins to discover the lack of freedom. Freedom is found in the choiceless awareness of our daily existence and activity. (. . .) Our action is based on knowledge and therefore time, so man is always a slave to the past."

DJ and LG: Buddhist and neuroscience through different methods come to the same conclusion: A unitary self and free will are constructs, i.e., they are conceptually designated. Both traditions see these constructs as acquired illusions. In cognitive neuroscience, acquiring them can be attributed a specific cortical interpreter module. In Buddhism we learn that the illusions can be overcome through introspective processes in mindfulness mediation, perhaps by broadening the function of the interpreter module and diminishing our blind dependence on subconscious processes.

THE MIND AND SOCIETY

DJ: Among the multiple subsystems in the brain, recent research has brought social centers in the brain to the forefront as well. Social behavior is essential to human survival and has co-evolved with our brains for millions of years (De Waal, 2006). Hence, behaviors such as child care, or smiling at others, are deeply wired into special neural networks in the brain, and are to some degree automatic. Altruistic behaviors and compassion towards other individuals have also been described in primates, elephants, and dolphins (De Waal, 2009). The most amazing and unique of human social behaviors is of course language, and multiple well defined brain areas are dedicated to sensory, semantic, and motor aspects of language processing (Kandel et al., 2021). Through language we are also educated during our upbringing about what behaviors are socially acceptable and meritorious, and are encouraged to strive towards such behavior. The memory of this education then becomes embedded in the information processing networks in the cortex that can help determine the course of our actions. Hence what it means to act morally is defined by our social interactions, often early in life, and moral behavior becomes shaped through our environment. As far as this morality is unique to the group that a person grows up in, so is moral behavior not necessarily defined in objective terms. Nevertheless, many core components of moral behavior such as child and family support, and working in small groups are essential to survival of human populations, and as such universal.

LG: According to Buddhist perspective, everything is dependently arisen and relative. The realization of this relative and dependent nature of all phenomena leads to the insight that nothing exists on its own, nothing has inherent existence. In this regard, the very understanding of good or bad is very much dependent on the social norm of a particular society. However, there are certain norms that are universal such as killing, lying or stealing being accepted as morally wrong.

The very insight about the relative nature of morality definitely helps one to not be judgmental of other people's behaviors, but rather develop a true compassion based on clear understanding of experiential reality. The very nature of compassion (Nyingje in Tibetan, Karuna in Sanskrit) is the absence of hatred, and when one gets rid of hatred, it becomes natural to develop compassion. As 8th century Buddhist master Shantideva said, "Since I and other beings both, in wanting happiness, are equal and alike, what difference is there to distinguish us, that I should strive to have my bliss alone?" (translated into by Stephen Batchelor, Shantideva, 1979).

DJ and LG: Again neuroscience and Buddhism come to matching concepts on this level, which can be succinctly summarized by the term "dependent origination," meaning that causal processes going far back in history determine our decision making and are not "freely" willed. Nevertheless, compassion emerges as a deeply rooted biological principle to support survival of a species, and it emerges in Buddhism as a clear moral principle when one considers the interdependence of all beings.

CONCLUSION

LG and DJ: Neuroscience and Buddhism both discover that our "self" is made of multiple interacting parallel processes, many of which are subconscious. The concept of a unitary self arises as an illusion from our embodiment and from a high-level cortical "interpreter" module that forms part of our consciousness. These insights have important implications for our understanding of free will as an illusion, but also of how the society we live in shapes important aspects of our decision making abilities. In an increasingly global community of societies we understand through the Buddhist insight that all living beings are interdependent, and that emotional balance and compassionate behavior can be imprinted on our brain circuits through mindfulness meditation. In science, research in animal and human behavior shows that altruism is built into our brains as a part of social behaviors that ultimately serve the survival of species.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://tibet.emory.edu/.

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DJ: Neuroscience content. LG: Buddhism content. Manuscript jointly written.

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Empowering Skepticism: Neuroethics Engagement with Tibetan Buddhist Monastics

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Neuroethics has been incorporated into neuroscience training through the Science for Monks program since 2016. In this article, I describe this in-progress effort and I consider how the program has changed since this first year to develop into a pilot program in community-engaged participatory research with the monastic community. The current goals of the project are to train the monastics in social science research skills as a means of empowering them to harness their deep knowledge of ethics and to bring it to bear on ethical challenges in neuroscience, neurology, and neurotechnology.

Keywords: community-based participatory, cross-cultural, Neuroethics, Buddhism, engagement

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INTRODUCTION

When I was first approached about incorporating neuroethics into neuroscience training forTibetan Buddhist monastics through the Science for Monks program, I was reticent. These are *monastics* after all. Shouldn't they be teaching me about ethics? In one version of the narrative of my work with the monastics (Specker Sullivan 2020), my hesitance was unnecessary, and I discovered that I did have something to teach the monastics, after all. In that version of the narrative, I am the protagonist, uncovering some hidden truths about myself and my research agenda through this unique cross-cultural encounter. But (perhaps thankfully) this is not that narrative. In hindsight, I could have been more reticent. Effective neuroethics engagement with the monastics requires repositioning my interests relative to their own and working to empower the monastic community to bring their existing knowledge to bear on neuroethics and to investigate the ethical issues in the brain sciences that are salient for them.

NEUROETHICS AND SCIENCE FOR MONKS

I was first invited to participate in the Science for Monks program in 2016, while a postdoctoral neuroethics fellow at the Center for Neurotechnology (CNT) at the University of Washington.[1] Eric Chudler, a neuroscientist and the center's Executive Director, had taught neuroscience through the Science for Monks program for several years. I was brought on board to pilot neuroethics lessons alongside his neuroscience lessons, while also conducting preliminary neuroethics research of my own. From the beginning, my position was an intermediate one between teaching and research, on

[1]Science for Monks, like the Emory-Tibet Science Initiative, partners with Tibetan Buddhist monastic communities in India for scientific and leadership training and research. The two organizations have similar aims and sometimes work in the same communities, but they are different organizations with unique leadership structures and funding schemes.

the model of cross-cultural exchange. I would share my own knowledge of contemporary neuroethics through a series of lessons; the monastics, in turn, would share their own perspectives on the intersection of ethics and the brain sciences through participatory exercises, surveys, and open discussion.

My background made me a good fit for this experiment. I had taught in Japan with the JET Programme and had studied cross-cultural philosophy for my Ph.D., including 2 years spent as a researcher in Kyoto, Japan at the Kokoro Research Institute. I had some theoretical and practical experience with Buddhism through Japanese Zen Buddhism, but I had not worked directly with Tibetan Buddhist monastics. Through the CNT, I had developed an "Introduction to Neuroethics" slide set that I had used when teaching public and student groups, and I had collaborated with a primary school teacher to develop neuroethics modules for her class, but I had never paired neuroethics directly with neuroscience, and certainly not in a cross-cultural context. Nevertheless, I had experience being embedded in unfamiliar environments with the goal of intellectual exchange (not only in Japan, but as the sole philosopher in a neural engineering lab) and I hoped to draw on this skill set to create a meaningful relationship between myself and the monastics.

That first trip was, as one would expect, a learning experience–I suspect for me more than for the monastics. I had planned to begin my lecture the way I usually do in the United States, by asking the students to define "ethics." It turns out that this pedagogical technique relies on a cultural cohesiveness that did not exist between me and the monastics. Not only do I not know Tibetan, but I had not anticipated the multiple translations of this term. Faced with the prospect that the word "ethics" had different meanings for monastics than for lay people, for teachers than for students, I soon walked back this broad, top-down approach. Better to begin with the particular ethical issues that arose within neuroscience and neurology, I reasoned, since these are not abstract concepts but concrete problems, thick with context.

This approach turned out to be more successful. I introduced the monastics to the "rubber hand illusion," where someone can be made to experience sensation in a rubber hand unattached to their body. I used the illusion as an entry to a discussion of how physical sensations in one's body can lead to the sense of body ownership, and how this might raise questions about the significance of neural prostheses that are fully integrated into one's body schema. They learned about cutting edge techniques in neurostimulation, and the types of feelings and thoughts that such stimulation can occasion. We argued, in my impromptu office hours, over whether brain stimulation could make someone "too happy" or could change their sense of self.

After the snafu over ethics language on the first day, the rest of the sessions went more smoothly. At the end of the 2-week joint neuroscience-neuroethics session, I administered a survey I had developed on-site from my background in neuroethics, my conversations with the monastics, and informal worksheets I had distributed during the neuroethics sessions, asking them a set of Likert scale questions about how they thought about various neuroethical issues. I worked with my Tibetan translator to create a consent procedure that would fit my review board's requirements, while also being intelligible to the norms of the monastic community, and this had been initiated at the beginning of the session.

Some results piqued my interest, namely the monastics' skepticism about neuroscience as a route to human well-being and achievement. Science, in their estimation, was a fast-moving train that, once on track, was hard to slow, even if misgivings about the direction had developed. I didn't think they were wrong, but I wanted to know more.

In 2017 I returned to India to conduct one-on-one interviews with senior monastics alongside offering neuroethics lessons to existing science classes in the monastic community, building from the groundwork of this first visit and the survey results. This time, I resolved to be more interactive, and to focus on the monastics' knowledge, rather than my own. I aimed to ask broad, open-ended questions to better understand how the monastics were thinking about the intersection of neuroscience and ethics. I would not ask them to define ethics, I resolved, but would phrase my questions as requests for advice from fictional characters in tricky situations that involved neuroscience, neurology, and neurotechnology. This was a way of engaging with ethical questions that was more familiar to the monastics. While the science was important, the central concern was the human predicament the characters faced. The work ethicists do with scientists and clinicians in North America and Europe isn't so different, after all.

The results were intriguing, although not entirely surprising (Specker Sullivan 2021). The senior monastics continued to express skepticism about the use of science and technology to improve human lives. In clear-cut cases, new medical developments played a salutary role; everyone could see that brain injuries, like a broken limb, were a problem that needed mending. But when it came to using medical technology for basic mental health, or even to boost mental performance, they were deeply skeptical. The structure of the questions, describing situations where people were ill, or near-death, and a decision needed to be made, privileged the kinds of situations that I saw as problematic. The questions I asked relied on unstated premises: when I offered the monastics a dilemma and asked them which of two branching paths to a solution they would take, they wondered why such a dilemma arose in the first place.

So, in 2019 I pivoted the neuroethics project once again, to pilot a project in which I hoped the perspective from my own position as an American neuroethicist would fade even further into the background. I would live at a nunnery and work with the nuns to develop a more participatory approach to neuroethics engagement. One motivation for this pivot was my hesitancy about the methods I had been using to engage the monastics in connecting ethics with neuroscience, which were drawn from the ethnographic theory I learned through my graduate work in Japanese Studies. Traditional ethnography, despite shifting to describe objects of study as "participants," does not really operate on equal partnership with the communities it studies. The locus of power remains with the researcher, who in designing the questions and the structure of the study decides what is important, and what is tangential, to the area being studied.

While my training in neuroethics grounds my expertise in this type of research, this is just to say that I have worked within a particular tradition of scholarship that is concerned with the intersection of science and questions about what we, as human beings, should do. If I wanted to get outside that perspective to appreciate what mattered to the monastics, I would have to rethink my methods.

PURPOSES AND METHODS OF NEUROETHICS ENGAGEMENT WITH MONASTICS

Rethinking my methods of engagement with the monastics meant reflecting on the fundamental aims of the project. Why, as a neuroethicist, was I working with the monastics in the first place?

What I realized early on was that engaging with the monastic community through neuroethics revealed a pathway to neuroscience training due to the affinities between the aims of neuroethics as a field and the ethical orientation of Tibetan Buddhism. While others have pointed out the connections between the scientific study of the mind and the monastics' rigorous attention to first-person mental experience in their meditation practices (Varela et al., 1991), a more fundamental link is the shared purpose behind both of our practices.

Without precluding science for its own sake, neuroethics asks scientists, technologists, and clinicians to consider the end goal for which their practices are used, and to consider what benefits and harms might result, what their own motivations are, and whether any individuals might be wronged in the process. Likewise, Buddhist practices aim at benefitting sentient beings, developing altruistic motivations, and avoiding fundamental ethical wrongs. In this way, neuroethics can provide a missing link between Buddhist practice and scientific practice, by facilitating reflection on why it is meaningful to seek to understand the world through these scientific and religious traditions alike.

Due to the intellectual connections between neuroethics and Tibetan Buddhism, programs such as Science for Monks and the Emory-Tibet Science Initiative open a door to engaging with the monastics as partners in research and education, beyond relationships as teachers and students. While both programs ostensibly are oriented around scientific training for the monastic community, they are better understood as programs of cross-cultural intellectual exchange. Indeed, numerous interdisciplinary research programs have grown out of each program, with the broad goal of mutual benefit.[2] The scientific community and the monastic community are both trying to improve the human condition, and each specialty offers one particular method of doing just that. Upon reflecting on this shared purpose, I began to consider how to engage the monastic community more fully as partners in exploring the connections between Buddhism and neuroscience through neuroethics.

One method for developing a partnership with the monastics is community-based participatory research, or CBPR. In part due to developments in qualitative research that have occurred within public health, CBPR has been advocated as a more equitable model of cross-cultural research (Israel et al., 2010). The goal of CBPR is to implement just and equitable research practices across culture and other barriers, such as race and class, that balance the relative privilege of the researcher with the empowerment of the local community to identify and to achieve their own goals. While CBPR has typically been employed in addressing health disparities, it has promise for research that aims at equitably investigating ethical issues with scientific and medical developments across cultures.

CBPR is sometimes defined not as a particular set of methods, but in terms of the attitudes of researchers who prioritize democratizing knowledge and deconstructing power such that the experiential knowledge of communities is prioritized, empowering those communities (Minkler 2004). Yet balancing power between researchers and communities can be exceedingly difficult (Postma 2008). Differences in institutional structure, communication style, decision-making authority, and so on can create barriers to equitable participation. So, while an attitude of collaboration and mutual empowerment is helpful, it only goes so far. Structures that allow for new methods of intellectual engagement are needed to encourage participation.

These procedural challenges with CBPR can lead to ethical challenges (Minkler 2004; Mikesell et al., 2013; Wilson et al., 2019). A key factor in successful CBPR is building trust with local communities such that members believe their community will be strengthened by collaboration, not taken advantage of (Blacksher et al., 2016). Yet that trust must be warranted, and not gained superficially. In other words, community trust is earned when researchers are trustworthy. Researchers must also understand their own institutional limitations, and not overpromise the terms of their engagement and the benefits they can provide. The central ethical concern with CBPR is the tension between insiders and outsiders (Mikesell et al., 2013). These tensions can come from a variety of sources, such as different values, expectations, assumptions, priorities, and beliefs. While communication and transparency around differences can mitigate the tension they might cause, these differences do not disappear.

Despite these challenges, community-based participatory methods have much to offer neuroethics engagement with Buddhist monastic communities who are participating in science education. As the monastics develop scientific fluency, they become better positioned to identify their values and priorities with respect to scientific practices and developments. Further, they gain the language with which to express concern and skepticism, as well as excitement and optimism, about the potential for scientific advancements to change significant dimensions of human life. Using CBPR methods for

[2]This is clear in the mission statements of the two organizations. Science for monks: "The mission of Science for Monks is to nurture leaders who are establishing the indigenous capacity of the Tibetan monastic community to engage in new science learning and dialogue" (http://www.scienceformonksandnuns.org/about/). ETSI: "The Emory-Tibet Science Initiative is committed to bringing together the best of the Western and Tibetan Buddhist intellectual traditions for the creation, development and dissemination of knowledge and practices that will benefit humanity" (https://tibet.emory.edu/mission.html).

neuroethics engagement is one way to empower the monastic community to make their ideas on the benefits and risks of scientific practices known and to potentially impact those practices.

My own community-based work with the nuns is still in the very early stages. In 2019, I spent 2 weeks at the nunnery, leading classes on ethical issues in science that were part science education, part social science methods training. The goal is to empower the nuns, through social science methods, to collect their community's perspectives on ethics in science, so that any resulting neuroethics scholarship is not driven by my own agenda or interests, but by theirs. In this research program, I aim to be an advisor on methods and processes but not on content.

It is due to the complexity of community-engaged work that I believe I could have been more reticent about my work with the monastic community at the outset. I was, admittedly, naïve in my certainty that with a short introduction, the monastics and I would be able to share an appreciation of ethical issues in the brain sciences. There are unstated premises about what science is and why it matters that need to be acknowledged before we can even imagine a discussion of what we ought to do with it. Nevertheless, while this program is still in its early stages, I am optimistic that, if completed, it would empower the monastic community to influence the global discourse on the ethical dimensions of scientific advancements. This is not to say that the monastics *need* engagement with neuroethics to facilitate their own empowerment. Their experience and knowledge is powerful, and it could impact neuroethics—if we can learn to acknowledge what is already there.

CONCLUSION: BENEFITS OF PARTICIPATORY ENGAGEMENT

Neuroethics engagement with the monastic community can link scientific study with Tibetan Buddhism's ethical aims; it can also spark consideration of the reasons why scientific engagement matters for the monastics. Just as with scientists, monastics are curious about the world and their own experience, they value truth and accurate explanations, and they would like to see the conditions for all inhabitants of the world improve. As scientists partner with monastics, they may begin to question why scientific practice is a valuable tool for the monastics, who already have centuries-old practices developed for similar purposes (e.g., in the field of medicine, mental and physical health). The monastics themselves can encourage this questioning, asking why certain scientific experiments are carried out or technologies pursued if they do not offer means to sustainable well-being. Treating the monastics as true partners in intellectual inquiry requires taking these questions to heart.

Yet taking up monastics' questions does not in itself distinguish an intellectual partnership. It is entirely possible to superficially entertain a set of questions while nevertheless focusing attention on questions that one considers more scientifically relevant. Developing an equitable partnership with the monastics requires science training that revolves around their interests and questions. As neuroethics engagement with the monastics develops, one challenge is to similarly structure neuroethics discussions around ethical issues the monastics care most about. This includes, for example, talking about animal sentience and whether it should alter the norms of scientific research. While many neuroethics programs avoid this issue due to its fraught political status, it is an issue that many monastics care deeply about and it deserves to be taken up more seriously.

One of the goals of neuroethics engagement in the Science for Monks program has been to build a skill set in social science research skills that empowers monastics to investigate neuroethical perspectives within their own community. The results of their study could have a profound effect on current neuroethics research programs. While much of neuroethics research embraces scientific and technological development, taking a "not if but when" approach, monastic-initiated research might ask us to reconsider the purposes for which scientific developments are pursued.

In the early years of scientific engagement with the monastics, programs necessarily proceeded through trial and error: seeing which projects worked and which failed and building scientific literacy among the monastics so as to work with them as partners. Neuroethics engagement represents the fruit of these efforts, allowing ethicists to work alongside monastics on issues of common concern. Now, the time is ripe to develop capabilities within the monastic community for collaborative neuroethics scholarship that emerges from their own interests.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Emory-Tibet Science Initiative: Changes in Monastic Science Learning Motivation and Engagement During a Six-Year Curriculum

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Led by His Holiness the Dalai Lama, the initiative taken by the Tibetan Buddhist monastic community to connect with western science and scientists presents a unique opportunity to understand the motivations and engagement behaviors that contribute to monastic science learning. In this study, we draw on quantitative data from two distinct surveys that track motivations and engagement behaviors related to science education among monastic students. The first survey was administered at one monastic university in 2018, and the second follow-up survey was completed by students at two monastic universities in 2019. These surveys assessed the reception of science education related to motivations among monastics and their demonstration of engagement-with-science behaviors. We also tested for variation over time by surveying students in all years of the science curriculum. We identified that monastic students are motivated by their perception that studying science has an overall positive effect and benefits their Buddhist studies, rather than negatively affecting their personal or collective Buddhist goals. In accordance with this finding, monastics behave in ways that encourage fellow scholars to engage with science concepts. Survey responses were disaggregated by years of science study and indicated changes in motivation and engagement during the six-year science curriculum. These insights support the relevance of considering motivation and engagement in a novel educational setting and inform ongoing work to expand the inclusiveness of science education. Our findings provide direction for future avenues of enhancing exchange of knowledge and practice between Buddhism and science.

Keywords: engagement, motivation, emory-tibet science initiative, science education, monasticism

INTRODUCTION AND BACKGROUND

Many theories and conceptual frameworks seek to describe and explain academic motivation and engagement. With the aim of gaining greater clarity in this space, there have been calls for additional co-consideration of motivation and engagement (Murphy and Alexander, 2000; Pintrich, 2003; Martin, 2007, Martin, 2009; Reschly and Christenson, 2012). In the present study we explore motivation and engagement of a unique sample of students: Buddhist monastic university students who participated in a curricular innovation to include science in their monastic education. The educational history of these students includes extensive philosophical training and little to no exposure to western science. We address questions about their motivations and engagement, specifically how these students perceive the value of the science curriculum and the extent to which they participate in activities related to science outside of the classroom. Our goal is to contribute to the ongoing conversation in the motivation and engagement domain through exploration of these concepts in a cross-cultural educational environment.

Motivation and Engagement

Motivation is often viewed as the process that initiates, energizes, directs, and sustains goal-directed activities (Schunk et al., 2012). This motivation process is considered to be a "private, unobservable, psychological, neural, and biological" factor (Reeve, 2012). The positioning of motivation as an internal psychological factor is supported by Ainley (2012) and Martin et al. (2017).

Cleary and Zimmerman (2012) distinguish between motivation and engagement, saying that 'will' reflects motivation and "skill" reflects engagement. This distinction aligns with a cognitive-behavioral conceptualization, with motivation more often seen in cognitive terms and engagement in behavioral terms (Martin et al., 2017).

Engagement positively predicts achievement and persistence and has even been referred to as the "holy grail" of learning (Sinatra et al., 2015). In contrast to motivation, engagement comprises "publicly observable behavior" (Reeve, 2012). Engagement is typically considered to reflect evident and external involvement with activities (Ainley, 2012; Martin et al., 2017).

Suggestions of an underlying connection between motivation and engagement propose that motivation leads to engagement (e.g., Kuhl, 1985; Anderman & Patrick, 2012; Reeve, 2012; Schunk et al., 2012). Longitudinal empirical data tentatively support the idea that motivation provides an impetus for subsequent engagement (Martin et al., 2017). Engagement also explains significant variance in subsequent motivation, ultimately suggesting that motivation and engagement are mutually reinforcing across time and ultimately comprise a cyclical process (Martin, 2012). Reschly and Christenson observe that "motivation is necessary but not sufficient for engagement" (2012).

Motivation and Engagement in Cross-Cultural Education

For the purposes of this study, in accordance with the findings above, motivation is defined as the perceptions of impacts of science learning that influence students' inclination, energy, and drive to continue with the education. Engagement is defined as the behaviors that reflect this inclination, energy, and drive.

Numerous surveys and instruments have been developed for investigation of motivation and engagement including: the Motivation and Engagement Scale (MES) by Martin (2010); the Motivated Strategies for Learning Questionnaire (MSLQ) by Pintrich et al., 1991; the Patterns of Adaptive Learning Survey (PALS) by Midgley et al. (2000); and the Student Engagement Instrument (SEI) by Appleton et al., 2006. These surveys were designed for use with specific age groups of students who are younger than our cohorts who are adult learners. For example, differences in target age are reflected in existing survey items assessing family support of learning. Additionally, items inquired about notes, formal tests, formal grades, which are not as relevant to the science learning experiences of monastics. Finally, existing surveys view future aspirations and goals through the lens of western education, asking questions about the kind of life that is desired as a grown-up (also a question for young students), succeeding later in life, and getting a good job. These are particularly ill-suited questions to ask of students who have dedicated themselves to minimalist Tibetan Buddhist monastic lifestyles.

The Inventory of School Motivation (ISM) by McInerney et al., 2001 has been implemented and assessed in the greatest variety of cultural contexts including with students who identify as Anglo-Australians, Migrant Australians, Aboriginal Australians, Navajo students, and Anglo-Americans (Ali and McInerney, 2005). Additionally, this inventory has been validated in educational settings in Hong Kong and the Philippines (Ganotice et al., 2012; King et al., 2012). The cross-cultural implementation and validation of the ISM supported its potential for use in the context of Tibetan Buddhist monastic science learning; however, similar to the others, this inventory is targeted to students at younger ages (e.g., referencing the role of parents).

Given the limitations of existing instruments in aligning with our study population age and our desire to ask questions specific to the context of students studying science with pursuit of Tibetan Buddhism as the main purpose of their education, we decided to create a novel questionnaire. Motivation and engagement theories have demonstrated validity within science learning experiences in some Western societies, and the relevance of this framework in other cultures remains underexplored. Pajares (2007) specifically called for careful consideration of cultural context in the investigation of academic motivation and consideration of engagement by extension. Here, monastic Tibetan Buddhist scholars reported the impacts of their experiences of science learning motivations and their behaviors that demonstrate engagement with science outside of the classroom.

Introduction of Western Science in Tibetan Monastic Education

The introduction of science in Tibetan monastic education originated from the vision of the Dalai Lama who called for comprehensive science education at Tibetan monastic universities. This call was based on decades of personal experience in dialogue with western scientists from which he concluded that, in many significant respects, Buddhism and western science share common purposes and complementary perspectives (Dalai Lama, 2005).

In 2013, monastic leaders in the Gelug Buddhist tradition decided to implement the science program, ushering in the most substantial curricular innovation in 600 years of monastic education (Gray and Eisen, 2019). The following year, a 6-years science curriculum comprising biology, neuroscience, and physics and supplemented by math and philosophy of science, was introduced in the three largest monastic universities of south India (Gray and Eisen, 2019). This curriculum had been piloted during a 6-years development phase. Introduction in the monasteries was incremental such that the first year of the curriculum was offered in the first year of the initiative, then curricular years one and two were taught the following year, and so forth until all 6 years of the curriculum were implemented. ETSI summer session courses are taught in both English and Tibetan. During class, western science instructors speak a few sentences at a time in English, then an interpreter translates the information into Tibetan. The Tibetan language has roots as a liturgical language for Buddhist teachings, "the language of *dharma*" (Tournadre, 2013). Given these origins, there were few terms for specific scientific phenomena prior to the introduction of science curricula. Through annual translation conferences, over 5,000 scientific terms have been added to the already rich Tibetan language (Gray et al., 2020).

Numerous factors influence the Tibetan Buddhist monastic experience of learning science in this context. Monastic students enrolled in science education are adult learners with a highly developed conceptual framework and are already scholars themselves. These students join the science curriculum after completion of approximately 13–17 years of Buddhist study. Monastic students progressed through each year of the science curriculum in sequence. For example, 5th year participants have been in the science program for 5 years. Examining monastic scholars' motivations and perceptions of this science education experience and related behaviors provides unique and valuable insight on how motivation, engagement and cultural factors can influence science learning.

METHODS

Study Approach

To characterize Buddhist monastics' motivations and engagement related to learning science in the ETSI program, we conducted two studies at two monasteries and time points to yield over 900 monastic survey responses that inform the present report. Specifically, the research questions that these surveys addressed are:

1) How do monastic students self-report their motivations in terms of the impact of science learning on their Buddhist studies?
2) How do monastic students engage in science activities outside of the classroom?
3) Do motivations and engagement related to science learning change during the six-year science curriculum?

Participants, Instruction, and Surveys

During ETSI summer workshops, monastic students attended science class four and a half hours per day, 6 days a week. For each science course (physics, biology, and neuroscience), they received instruction for 7 days, reviewed material on the eighth day, and took a final exam in each topic area at the conclusion on instruction. Each class was led by a teaching team consisting of two visiting faculty, two translators, and a monastic teaching assistant. First- and sixth-year students took an additional class discussing the philosophy of science to bridge their training in philosophy with their science education. Since the workshop was held annually for 6 years, students began science education learning fundamental concepts of each discipline in the first year and pursued topics of increasing complexity through the sixth year. In neuroscience, for example, Year 1 students were taught basic concepts of the neuron, the action potential, and functional neuroanatomy, while Year 6 students grappled with language processing, learning and memory, and consciousness.

A variety of active learning strategies were employed to maintain monastic engagement with science learning, including techniques used by monastics in their own Buddhist study such as debating and the Socratic method of asking and answering questions to engender critical thinking, and traditional western techniques such as hands-on labs, experimentation, and computational learning through interactive videos.

This study aimed to track perceptions and behaviors of Buddhist monastic students as they underwent this novel forum of science education over the six-year curriculum. To this end, two distinct surveys (see **Supplemental Material**) were administered to study how monastics' perceptions and behaviors related to engagement and motivation in science learning and the extent to which studying science affected their Buddhist studies. Further, to investigate how perceptions change over time, and whether they are commonly held across different monastic populations, responses were compared across years of study in the program and at two different monastic universities.

Study 1:

In 2018, monastics from curriculum years 1–5 at Sera Jey Monastic University participated in a survey at the end of the summer session (n = 214). This survey collected self-reported demographic data including level of English proficiency, science education background, and years of participation in the summer science program (**Table 1**). To investigate monastics' perceptions of the role of science in relation to their Buddhist studies, students selected prompts categorized as describing either positive or negative perceptions. Positive perceptions included whether science played a role in shaping, engaging, understanding, or validating Buddhist studies. Negative perceptions included taking away too much time, being a distraction, a contradiction, or not useful for Buddhist studies. To examine specific behaviors resulting from their perceptions and exposure to science, participants rated frequency of hearing, using, and accessing science learning materials outside of class time, as well as their likelihood of encouraging fellow monks to study science on a 5-point Likert scale (1 = none/never, 5 = strongly likely/very often).

TABLE 1 | English language proficiency and science education background among monastic students taking Emory-Tibet Science Initiative (ETSI) science classes in summer 2018 (n = 214).

English language proficiency	Participants (%)
I don't Understand any English	44
When Someone Speaks English, I Understand 50% or more of what is said	51
I am fluent in English	5
Science education background	
I have only studied science in the ETSI Program	46
I have Studied Science in a Secular School	14
I have Studied Science independently	34
I have Studied Science in other Science Programs for monastics, Beyond ETSI	7

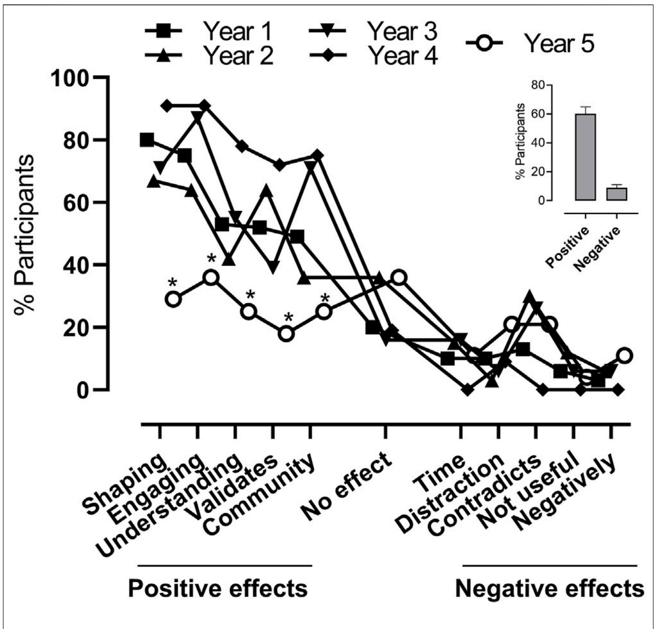

FIGURE 1 | Monastic students' perceptions on effects of learning science at Sera Jey Monastic University (2018 study) In summer 2018, Tibetan Buddhist monastic students reported a robust appreciation for the positive versus the negative effects of learning science on their Buddhist studies; determined by the frequency of survey responses as a percent of participants in each year (n = 214). Each symbol is representative of data from students in different years of the science curriculum. The words chosen as graph labels are underlined in the full prompt (**Supplemental A**, number 7). Overall percent of participants endorsing positive and negative perceptions are quantified in the inset.

Study 2:

To assess the generalizability of initial findings from Study 1, and to probe whether observations at Sera Jey were similar to those at another site where the ETSI program was implemented in a similar fashion, Gaden Monastic University (400 km from Sera Jey), a second survey was administered in 2019 at both Sera Jey (n = 427) and Gaden (n = 296) Monastic Universities to students who participated in years 1–6 of the program. This survey tapped monastic perceptions of gains from participation in the ETSI program at their monastery, including learning science content knowledge, personal gains, and benefits to their Buddhist studies. Participants rated these contributions on a 5-point Likert scale (1 = none/never, 5 = strongly likely/very often).

Translation of surveys used in both Study 1 and Study 2 from English to Tibetan was performed by an experienced monastic translator and then independently verified by a second senior non-monastic translator. Students responded to online surveys given to entire classes in the presence of both the Tibetan-English translator and the western science instructor. All surveys were administered upon completion of the year's ETSI summer program. Survey questions are included as supplemental materials (**Supplemental Material**). Although prompts were communicated to students by English-Tibetan translators, we cannot be sure that definitions, conceptualization, and interpretation of terms were consistent among all survey responders. This is difficult to achieve even when survey items are generated and responded to in the same language and similar cultures (Limeri et al., 2020).

Data Analysis

In the 2018 survey, students were presented with 10 items (five positive and five negative) and asked to choose all items that described their perception of their science learning experiences. The percentages of participants who chose each of the five positive and five negative items were compared across all years of study. A two-way ANOVA examined perceptions (positive, negative) for all years of study (1–6), and their interaction. To assess specific behaviors related to length of exposure to science learning (2018 study) and to investigate the overall associations of science study to science content knowledge, personal gains, and Buddhist studies (2019 study), responses on 5-point Likert scales were averaged, and data are presented as the mean and standard error mean of responses. ANOVAs analyzed behaviors, year of study, and their interaction. For all ANOVAs, Tukey's multiple comparisons post-hoc analyses were conducted to investigate group differences, and effect sizes are reported as R^2. Analyses were conducted in GraphPad Prism version 8.3.0; criterion for significance was $p < 0.05$.

RESULTS

Student Background

To characterize relevant background differences among Tibetan Buddhist monastics in the context of science education, information was collected on English language proficiency and science education history from ETSI students at Sera Jey monastery in summer 2018 (**Table 1**). Responses revealed that 5% of surveyed students were fluent in English (n = 214) and 51% understood at least half of the content communicated through spoken English. Nearly half of the students (46%) were exposed to science education only through the summer intensive ETSI program, 14% of students had studied science in a secular school before joining the monastery, and 34% studied science independently. Anecdotally, students with previous English and/or scientific knowledge often facilitated knowledge exchange in the classroom.

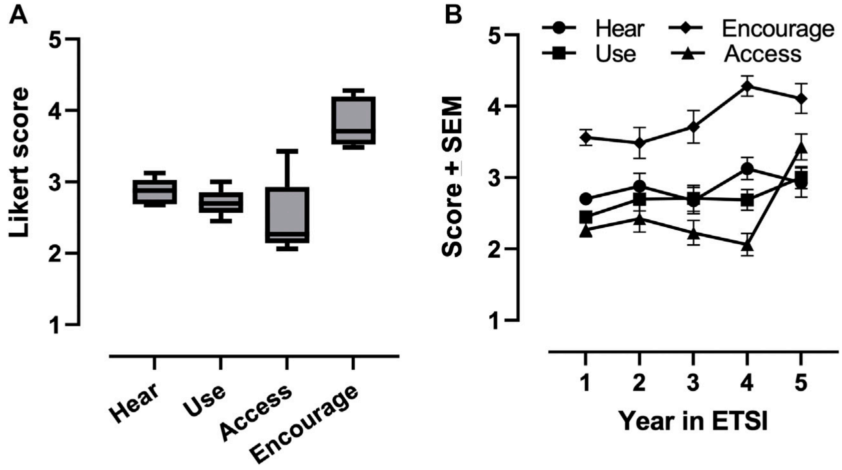

FIGURE 2 | Monastic students' science learning behaviors at Sera Jey Monastic University (2018 study) **(A)** Willingness to encourage fellow monastic students to study science was rated significantly higher on a Likert-type scale of 1-5 than practical behaviors of hearing science words, using science terms, and accessing science content outside of ETSI (n = 214). **(B)** Disaggregated by year of study in ETSI, monastic student levels of engagement increased as a function of years in the program. In particular, accessing science materials significantly increased with Year 5 students compared to all other years; $p < 0.0001$; Tukey's test. Each symbol is representative of a different science learning behavior.

Monastic student perceptions and behaviors related with ETSI science education at Sera Jey Monastery (Study 1, 2018)

A high percentage of monastic students endorsed positive effects of studying science on their Buddhist philosophical and religious studies (**Figure 1**, inset). Across all years of participation in the science curriculum, 57 - 71% of monastics identified some positive effects, while only 4 - 30% of monastics selected negative effects. The number of reported positive and negative perceptions differed significantly, F (1, 4) = 19.88, $p < 0.05$, $R^2 = 0.74$.

Among positive statements, those most frequently selected across all years of science study were that science learning helps in: 1) engaging other philosophies in understanding Buddhism (70.6%) and 2) shaping what it means to be a monastic in the 21st century (67.6%). Further analysis detected a significant and robust effect of years in the program on positive perceptions of studying science, F (4, 16) = 23.85, $p < 0.0001$, $R^2 = 0.70$. Notably, year 5 responses were significantly lower for all positive effects compared to those of students in early years, $p < 0.0001$. Among the negative statements, the most frequently selected across all years of science study were that learning science: 1) contradicts Buddha's teachings with respect to origins of life and the universe (18%) and 2) harms my Buddhist studies because it requires too much time. (10.4%). We observed a significant effect of years of study (F (4, 16) = 3.35, $p < 0.05$), but with a small effect size, $R^2 = 0.30$, in which Year 4 students less frequently endorsed four of the five negative effects compared to students in all other years.

With respect to science learning behaviors, monastic students in all years of study strongly endorsed the likelihood of encouraging fellow monastics to study science, with the highest mean Likert scores (3.8 ± 0.1), and with lower scores on hearing (2.8 ± 0.1), using (2.6 ± 0.1), and accessing (2.4 ± 0.1) science concepts outside the classroom. (**Figure 2A**). To further investigate trends in engagement with science material outside of class, a two-way ANOVA revealed a significant effect of year of study on reported behaviors F (4, 1,040) = 13.77, $p < 0.0001$, R^2 = 0.04 and a significant interaction between year of study and behavior, F (16, 1,040) = 2.49, $p = 0.001$, $R^2 = 0.03$. (**Figure 2B**). In particular, Tukey's post-hoc tests comparing all possible combinations revealed that Year 5 students more frequently reported accessing science information in the Tibetan language than did students ($p < 0.0001$, comparing Year 5 to all other years). Furthermore, scores on the relevance of science in Buddhist studies and on encouraging fellow monastics to study science significantly increased over time, based on comparison of Year 1 to Year 4 responses ($p < 0.01$, comparing Year 1 to Year 4 responses).

Monastic student perceptions regarding benefits of science learning at Sera Jey and Gaden Monastic Universities (Study 2, 2019)

The second study aimed to elicit additional perspectives on the benefits of science education. At both monasteries, monastics reported significantly lower mean scores on actually learning science as a benefit of participation in the science curriculum, compared to personal gain or benefits to Buddhist studies, $p <$ 0.0001 and $p = 0.0003$ for Sera Jey and Gaden, respectively (**Figure 3A**). Further comparison by two-way ANOVA (monastery x benefit) revealed no significant interaction or difference between the two monasteries for each perceived benefit F (2, 2,169) = 0.26, $p = 0.61$.

Analysis of responses by year of study in ETSI revealed that for both monasteries, all perceived benefits increased among students from Years 1 through 4, yet mean Likert scores were lower among Year 5 and 6 students (**Figure 3B**). Two-way ANOVAs identified

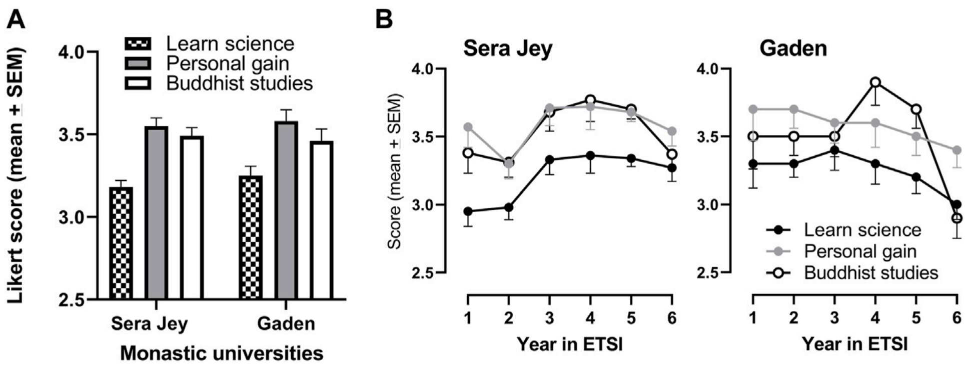

FIGURE 3 | Monastic students' perceptions on benefits of learning science at Sera Jey and Gaden Monastic Universities (2019 study) **(A)** At Sera Jey and Gaden monasteries, monastic students rated learning science content as a benefit of participation significantly lower on a Likert-type scale of 1-5 compared with personal monastic gain or benefits to their Buddhist studies, $p < 0.0001$ and $p = 0.0003$ for Sera Jey and Gaden, respectively. **(B)** At Sera Jey and Gaden monasteries, all perceived benefits increased as students responded from Year 1 to Year 4, and Likert scores began to decline for the Year 5 and 6 students. Each different circle style is representative of different perceived benefits of learning science.

a significant effect of participating year in science curriculum on reported benefits gained by science education, F (5, 1,260) = 6.5, $p < 0.0001$, $R^2 = 0.02$ and F (5, 999) = 3.7, $p < 0.01$, $R^2 = 0.02$, for Sera Jey and Gaden, respectively.

DISCUSSION

Monastic students report a robust appreciation for the positive effects and benefits of studying science on their Buddhist studies

The robustly positive effects we observed likely are linked primarily to the perceived connections between science learning and enhancing Buddhist studies. For example, the most frequently selected positive effects of studying science were that 1) it contributes to shaping what it means to be a monastic in the 21st century and 2) it is a means of engaging other philosophies to help the development of Buddhist philosophy (**Figure 1**). Students also affirmed that science learning benefits their Buddhist studies and produces personal gain to a significantly greater degree than the inherent learning of science (**Figure 3A**). These findings detail specific positive perceptions that monastics endorse about their science learning experience. Notably, these findings are found in the Year 1 through Year 4 students, whereas Year 5 monastics' positive perceptions declined significantly. This difference could be attributed to two opposing forces. Year 5 and 6 students begin preparing for the rigorous Gelug exams, while Years 1 through 4 are enthusiastic for the summer enrichment that ETSI brings, temporarily changing the demanding year-round schedule of the monasteries.

Monastic students enthusiastically encourage fellow monks to engage in and study science

As shown in **Figure 2**, students reported on average that they "sometimes" 1) hear science terms being used by Tibetan monastics (e.g., in conversations, debates, teachings), 2) use science terms outside of the summer program, and 3) access science content in the Tibetan language on the internet, social media, news, or radio. In contrast, the likelihood of their encouragement of fellow monastics to study science was significantly higher.

Despite the strength of personal beliefs that science learning can positively influence their Buddhist training, the significantly lower scores on hearing, using, and accessing science compared to building a community of science-learning monastics, suggest that the practical utility and frequent exposure to science concepts may be limited. Such a finding indicates that conceptual buy-in is farther along than the more pragmatic coordination aspects that are needed to more effectively promote science learning behaviors outside of the ETSI classroom.

Personal and behavioral factors related to learning science change with science exposure across the six-year science curriculum

A notable finding of this study is the change in perceptions and behaviors related to science learning as a function of year in the ETSI program. As monastics participate in consecutive ETSI summer programs from years 1 through 4, they increasingly report positive effects of the experience (**Figures 1**, **3B**), are more likely to refer to science concepts outside of the classroom setting, and increasingly encourage fellow monastics to pursue science education (**Figure 2B**). However, monastic students' perceptions on the benefits of science education significantly decrease in Years 5 and 6 (**Figures 1**, **3B**, respectively). We suggest that these changes are attributable to the competing demands of participation in the ETSI summer program against increasing pressure to study for the Gelug Buddhist exams taken by many Year 5 and Year 6 students. As monastics reach advanced stages of their Buddhist studies, they become eligible to start taking the Gelug exams for the highest academic Geshe degree. Monastic students in Years 5 and 6 expressed concern that participation in science studies eroded time for adequate preparation for those all-important exams. For example, it was reported by monastic science directors that scholars enrolled in these years sought exemption from labs (Sera Jey) or from the science classes entirely (Gaden). By contrast, monks in the early years of ETSI may be more likely to participate in science activities throughout the year, in addition to the ETSI summer program.

Consistent differences in monastic students' perceptions of the benefits of learning science in the earlier versus later years of science exposure are maintained across two monasteries, as well as in Study 1 (2018) and Study 2 (2019) (**Figures 1**, **3**). The pressure of limited time to study while attending science classes appears to be a barrier to sustainability of positive science learning perceptions. Nevertheless, the inclusion of formal science knowledge assessment on the Gelug Buddhist exams appears to stimulate students accessing science education materials (**Figure 2B**), consistent with the need to study and prepare for the science sections of the exams.

Incorporating more frequent, habitual exchange of information *via* routinization of science classes throughout the entire year (not only summer) may enhance the currently modest access to science reported by students in Years 1–4. Implementation of such a year-round class schedule is underway. Encouraging incremental, time-distributed and structured use of science learning materials outside of class in Years 1–4 may buffer disaffection from science studies among Year 5-6 students (**Figures 2**, **3**, and 4) by better preparing them for science questions in their Gelug exams, and reducing the scramble to access science materials in years 5 and 6 (**Figure 3B**), thereby lowering conflict with urgent demands for Buddhist studies.

Implications and Broader Impacts on Science Education

Motivation

Here we have considered motivation and engagement of monastic students in science. Our findings frame the driving force behind monastic scholars' motivation for learning science in terms of their personal grounding in and dedication to the study of Buddhism. The quantitative data presented here show that acquiring science content was the least frequently endorsed benefit of the ETSI experience, compared to personal gain as a monastic, or advancing their Buddhist studies. Qualitative analysis of monastics' interview statements in a separate parallel study, also found that students consistently drew associations between Buddhist training and their appreciation of science education (Worthman et al., *this issue*). The overarching interest in ETSI science education opportunities appears to arise from monastics' perception that science may offer fresh knowledge and insight (Worthman et al., *this issue*), which aligns well with values and practices in the Tibetan Buddhist monastic culture oriented to knowledge attainment and understanding.

Our results underscore the necessity of student-centered curriculum and instruction across cultures and scientific backgrounds in order to maintain student motivation to learn (Stebleton et al., 2012). Non-STEM students taking science courses to fulfill college General Education requirements are similar to our monastic science students in that future aspirations are not necessarily centered on science. Monastics' biology questions related primarily to personal interests and experiences. For example, they are intrigued by the sensory system which renders us sentient beings; the abstract nature of the mind versus physical brain; and the physiological underpinnings of meditation. Pursuit of this type of knowledge maintained their motivation to learn. This is consistent with the suggestion that exploring connections between science course materials and the strengths, values, and aspirations of our learners enriches and promotes discussion of science through a multi-disciplinary lens (Stebleton et al., 2012). Future studies that formally investigate first-order factors that comprise motivation, a higher order factor, will complement the findings of this current study. Such first order factors include: self-efficacy, valuing, and mastery orientation (Martin et al., 2017). In particular, documenting changes in these constructs over time will provide valuable insight into the unfolding effects as monastic science education progresses.

Engagement

In addition to assessing motivation, engagement was considered in terms of behavioral factors to determine the actualization of perceptions of motivation. Survey responses in the present study and interview responses in Worthman et al. (*this issue*), indicate that monastic students value science education for advancing their pursuit of enlightenment and are motivated to learn. The extent to which this motivation translates into active engagement with science-seeking behaviors outside of class changes throughout the course of a student's science learning. The hypothesized primary cause of these changes is increased time demand for Buddhist studies as students progress through this parallel coursework. Advanced monastic Gelug exams take place in the 5th or 6th year of the science curriculum. To investigate the long-term effects of science learning, further studies that examine behaviors of monastics who have completed the 6th and final year of the ETSI program are warranted.

We propose that inclusion of more science topics and more opportunities throughout the year to explore science in this traditional monastic setting, and use of monastic learning styles such as debate can facilitate increased engagement and a more complete integration of science education into the monastic curriculum (Tillemans, 1989). Additional investigation of first-order factors that are components of engagement, including planned behavior and monitoring, task management, and persistence (Martin et al., 2017), will expand the foundation provided by this current study. In particular, exploring the development of these constructs over time in parallel with first-order factors of motivation (self-efficacy, valuing, and mastery orientation) will enrich the knowledge of co-consideration of these concepts.

Motivation and Engagement for Program Sustainability

Students' motivation and engagement related to learning play a significant role in retention and enrollment (Seymour and Hewitt, 1997; Gasiewski et al., 2012). It is therefore important to consider our findings in relation to ensuring the longevity of the partnership between science education and Buddhist monastics. Gathering information about the current state of monastic scholars' motivation and engagement with science education is key to the sustainability of this endeavor.

Our study reports on a novel setting for engendering student motivation and engagement in science learning. Moreover, our findings provide evidence that implementation of a science education summer program for a culturally diverse and non-STEM student body can be successful if implemented over several consecutive years. Because of the highly preserved traditions of the Tibetan Buddhist monastery culture, we make the assumption that the language proficiency and science background of the monastic students collected at Sera Jey are likely to be very similar to those of the students at Gaden monastery. Nevertheless, regardless of the possibility of differences in these specific demographics, our findings support marked similarities across the two institutions for the outcomes measured.

We observed changes in motivation and engagement over the course of the six-year curriculum. We predict that changes will continue as these students move on to the next stages of their training. Additionally, we may expect changes in the motivations and engagement of new, incoming students as they join the science curriculum at different stages of its institutional maturity.

Now that all 6 years of the science curriculum have been fully implemented, focus has turned to building science pedagogy skills among monastics and lay Tibetan scientists who henceforth will conduct the science program. In partnership, the monastic universities and western universities are currently undergoing a shift of primary science teaching responsibilities from visiting science professors from abroad to science classes taught by Tibetan Buddhist monastic instructors and lay Tibetan instructors in the community.

Success during this stage is key both to the sustainability of the program and evolution of the curriculum within the Tibetan Buddhist monastic teaching and learning context. Drawing on knowledge of student motivations and engagement will fully realize the enormous potential of students as co-creators of content and teaching approaches.

An encouraging practice to emerge from this partnership is the increasing collaboration and engagement between monastics and Western scientists on original scientific research resulting in publication of books and articles, including Buddhism-informed science education and neuroscience research investigating brain activity during monastic debate (Lakshmi, 2017; Eisen and Kunchok, 2018; van Vugt et al., 2018). Public health projects related to diabetes, depression, and water quality have also been initiated in the monastic communities.

Monastic science education will build on this momentum to increasingly incorporate monastic students as co-creators of science content through explicit discussion between science and Buddhist concepts and utilizing monastic-specific teaching approaches, e.g., debate between a challenger and a defender (Tillemans, 1989; Osborne, 2010; Simmons and Prunuske, 2015). Western Biology educators realize the enormous learning potential of students as co-creators of content and teaching approaches such as active peer-mentoring in supplemental instruction (Achat-Mendes et al., 2020), and in this second phase, the train-the-trainer model will employ monastic students as co-creators of science curriculum.

Notably, the intentions of monastic education differ markedly from traditional western education. Specifically, in Tibetan Buddhist monastic education, studies are undertaken with the lifetime aim to transform the mind toward attaining enlightenment, a process that generally takes many lifetimes. This presents a very different worldview and context to learning motivations as compared with those common in western education. Academic studies are often undertaken in western society with the goals of proving oneself, gaining status, accreditation and earning a high wage in a career.

Future studies untangling the myriad of possible effects these long-term goals may have on more immediate science learning perceptions will provide valuable insights. For example, a longitudinal study could be conducted by selecting students in their first year of science study and observing changes in learning motivations and engagement with science over time. Future studies may continue to consider motivation and engagement in order to gain additional insights into the cross-cultural applicability of this approach. Findings related to this student population provide unique insights relevant to understanding the breadth of motivations that students bring to the classroom and the diversity of means of engagement.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Emory University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. The Institutional Review Board of Emory University approved the procedures for this study (IRB00073805). Given the de-identified and archival nature of the data, an informed consent process was not required.

AUTHOR CONTRIBUTIONS

All authors listed have made substantial direct and intellectual contributions to the work, and approved it for publication. Specifically: Study concept and design: all authors. Data collection: CA-M and CW. Data analysis: CA-M, KG, and AK. Writing: KG and C-AM with feedback from all authors.

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Integrating Authentic Research Into the Emory-Tibet Science Initiative

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We are at a historic point in which scientists and Tibetan monastics are working together to investigate ancient questions of mind and matter, and to serve the best interests of humanity. To facilitate this collaboration, His Holiness the Dalai Lama supported the development of the Emory University-Tibet Science Initiative (ETSI), which reflects the first major change in the Tibetan monastic curriculum in six centuries. Over the course of a 6-year long curriculum, Tibetan monastics living in India have the opportunity to study science with experts in various disciplines. In 2019, ETSI graduated its first cohort of monastic students from a 6-year "implementation phase," and now has entered the "sustainability phase." A goal of the sustainability phase is to broaden the scope of ETSI and begin training monastics through research. The present paper provides an overview of a 3-year Research Training Program being developed for the sustainability phase. We first overview a pilot program that informed feasibility and potential structure for a broader Research Training Program at the monasteries and monastic universities in India. Next, we discuss the conceptual framework for the Research Training Program and four learning objectives that we hope to attain. We then discuss the specifics of the course design for the proposed 3-year research training curriculum, through which our goal is to transition from a more guided training experience to a less guided experience. Finally, we discuss challenges and opportunities that we expect to encounter in developing and implementing the program.

Keywords: research—development-innovation, education—active learning, buddhism, neuroscience, international and comparative education

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INTRODUCTION

For many years, the Dalai Lama has engaged in a conversation with scientists to examine how academic science and the time-honored wisdom of Indo-Tibetan traditions can work together to best serve the interests of humanity. These conversations highlight important similarities in the investigative spirit between academic science and Buddhist thought. Both science and Buddhism are committed to an empirical investigation of reality. They also share a willingness to discard long-held positions if such investigations suggest that reality is different than existing models or theories (Ladyman, 2002; Dalai Lama, 2005). For example, although Buddhism is a religion with a body of scriptures and rituals, Buddhist scriptural authority, according to the Dalai Lama, cannot outweigh an understanding based on reasoned examination and experience (Dalai Lama, 2005; Jinpa, 2010).

Despite their shared commitment to an empirical mindset, science and Buddhism frequently differ in their methods. Science typically takes a third-person perspective involving measurement, quantification, and verification through experiments (Popper, 1959). Buddhism, by contrast, highlights the importance of a first-person perspective and the direct observation of both inner and outer states, as well as reason and analysis (Wallace, 2003). Many scientists and Buddhist thinkers, including the Dalai Lama, believe that we are at a point in history where these two traditions can, and should, start working more closely together to help humanity meet its challenges (Davidson and Lutz, 2008; Eisen and Konchok, 2017). To facilitate this relationship, the Dalai Lama has been working with Emory University for over 20 years on initiatives to increase cross-talk between science and spirituality. As this collaboration progressed, it became evident that Tibetan monastics needed more specific training in academic science to fully participate in the dialogue (Sonam, 2019). The Emory-Tibet Science Initiative (ETSI) emerged from this insight (Eisen and Konchok, 2017).

ETSI is an historic educational project conceived and supported by the Dalai Lama, and formally launched in 2008 by Emory University in collaboration with the Library of Tibetan Works and Archives in India (Sonam, 2019). The goal of ETSI is to integrate academic science into the education of thousands of displaced Tibetan Buddhist monks and nuns living in India, reflecting the first major change in the monastic curriculum in six centuries. Supported by ETSI, Tibetan monasteries and monastic universities have hosted international science educators from dozens of universities for an annual science curriculum intensive for monks and nuns. Over the course of a 6-year long implementation phase covering philosophy of science, physics, neuroscience, and biology, monastics study science with experts in various disciplines. A goal of ETSI is to build a bridge between two complementary systems of knowledge by educating future scientific collaborators in the study of mind and body. In addition to helping provide Tibetan monastics new tools for understanding the world, the academic scientists and educators are encouraged to learn more about the Buddhist science of mind and what it can contribute to our understanding of consciousness and integrative approaches to health and well-being.

In 2019, ETSI graduated its first cohort of monastic students from the implementation phase–a total of 233 monastics from nine monastic academic institutions–who completed the 6-year science curriculum, and ETSI now has entered the "sustainability phase." At the time of the publication of this paper, approximately 60 monastic students have begun the sustainability phase. All of these students have completed at least four of the total 6 years of the ETSI implementation phase and have demonstrated a strong interest in continuing to learn more science both for their own knowledge and to become better teachers of future monastic ETSI students. One goal of the sustainability phase is to help Tibetan monastics develop an understanding of the conceptual and theoretical foundations of the scientific process by doing research. This new direction in ETSI opens up a number of exciting opportunities for Tibetan monastics and academic scientists. First, it aligns with the body of literature that emphasizes the value of doing science in order to learn science (National Research Council, 2003; National Research Council, 2012). Second, it should provide monastics an opportunity to identify the similarities and differences in the empirical modes of investigation between science and Buddhism. Third, it will allow monastics to move from acquiring scientific knowledge to generating and using scientific knowledge to ask questions and solve problems (Balgopal et al., 2021). While teaching science in traditional classroom settings exposes students to facts and concepts, and guides them towards a better understanding of natural phenomena, science also includes the process of identifying patterns and testing hypotheses in order to gain novel insights (Russell, 2001). Numerous studies have demonstrated that engaging students in the process of doing science increases interest in science and helps students have a deeper understanding of the material (Furtak et al., 2012; Marshall et al., 2017; Labouta et al., 2018). For these reasons, the ETSI sustainability phase will help monastics design and execute research projects. In doing so, the ETSI research training program will facilitate the Dalai Lama's goal of generating collaborative relationships between scientists and monastics to investigate the mysteries of mind, emotion, and consciousness.

ETSI is in the early stages of developing and implementing what will be a 3-year Research Training Program for the sustainability phase. Here, we provide an overview of the conceptual foundations and planned structure of this training program.

A RESEARCH TRAINING PILOT PROJECT

To explore the challenges, opportunities, and feasibility of establishing a research program, ETSI facilitated a research training pilot program in conjunction with the inauguration of the Drepung Loseling Meditation and Science Center in India in 2017. The pilot program was designed for monastics to develop authentic research projects, building on both their own interests and on the training that they had received in the biological sciences through the ETSI curriculum. Four of us (Balgopal, Shreckengost, Mascaro, Gerardo) led the 8-day long workshop. We capitalized on the literature on Course-Based Undergraduate Research Experiences (CUREs) as a framework, which emphasizes context, discovery, iteration, ownership, communication, and presentation (Auchincloss et al., 2014; Staub et al., 2016). Because one of the goals of ETSI is to prepare some monastics to become science teachers, we modeled best pedagogical practices by limiting lectures and letting monastics explore topics through active participation. In this way, we demonstrated that inquiry-based teaching can support research inquiry. In both research and active learning, individuals ask questions, identify what background knowledge they have, what new knowledge they want, and how they can best generate the new knowledge. As a student, this may mean that one identifies what active learning approaches are effective for them. As a researcher, this may mean clearly articulating research goals and design before embarking on the study.

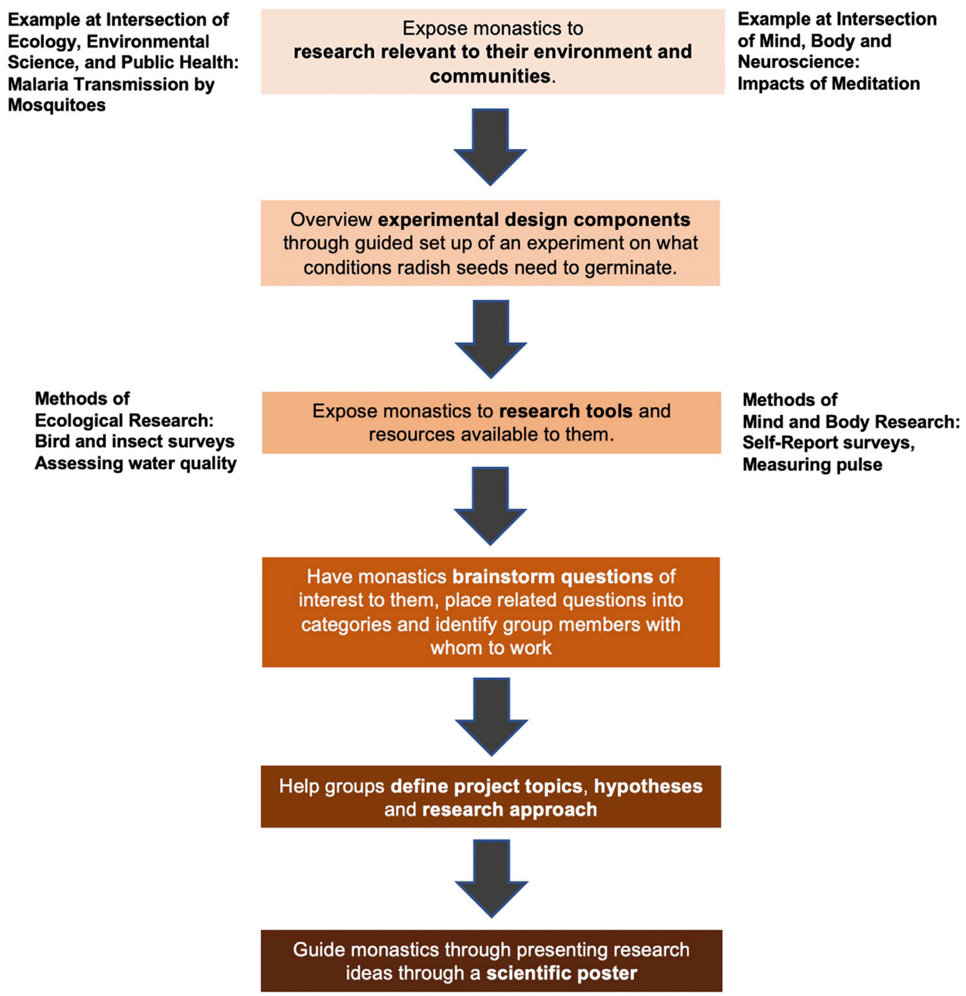

FIGURE 1 | Overview of components of ETSI research training pilot workshop.

Following the core characteristics of active learning and CUREs, in the first days, we overviewed the scientific process through designing a group experiment and presented research that monastics and their communities would find relevant (**Figure 1**). We focused on research in two broad themes: 1) Ecology, Environment, and Public Health and 2) Mind and Body. We described an array of research methods used in these fields. For example, we collected local water samples and talked about methods to identify mosquito larvae, an important concern given the prevalence of mosquito-vectored diseases in India. We also demonstrated methods to collect data on heart rate variability and other health measures, some of which have been studied in relation to the meditation practices central to Tibetan Buddhism (Peng et al., 2004; Phongsuphap et al., 2008). The monastics were given time to propose questions that were of interest to them and confer with one another as they formed research teams. Each team, through guided instruction, generated a hypothesis, research design, and plan for collecting data. They created posters, much like those presented at scientific conferences, to communicate their research plans.

From this pilot, we learned many things. First, the pilot made it clear that the monastics have diverse interests that are shaped by their lived experiences. While we expected the monastics to gravitate towards research projects related to meditation, a practice central to Tibetan Buddhism, this expectation was narrow and naïve. One group of monastics, for example, developed a research proposal on how gardens could impact both the presence of pollinators and human happiness. Other proposals focused on health of the monastic community, highlighting concerns about weight gain and exposure to environmental toxins, a global concern. In other words, monastics demonstrated a wide range of research interests that were contextual and focused on both physical and mental health. Going forward, the Research Training Program will benefit from capitalizing on these interests. Second, the pilot emphasized what many instructors in the first phase of ETSI learned: the monastics bring a unique perspective that can shape our perceptions of the world and research going forward. We recognize that, although monastics may engage in research projects in similar ways as their ETSI mentors from the U.S., their motivation to pose questions in

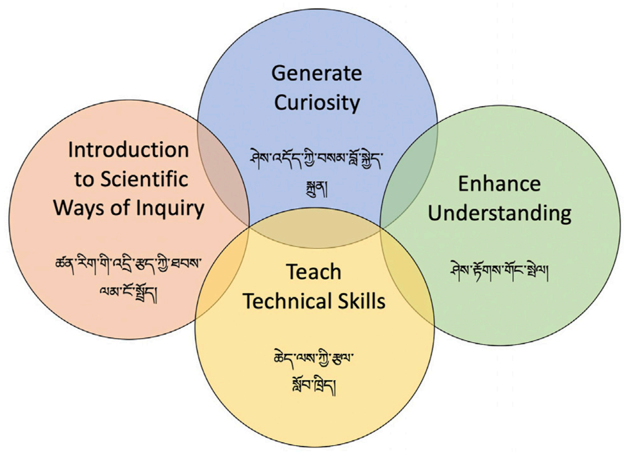

FIGURE 2 | Four learning objectives for the Emory-Tibet science initiative research training program.

certain ways is likely shaped by their own worldviews and epistemologies (Motokawa, 1989). Third, doing scientific research takes time, and the monastics, like traditional academics, have many demands on their time. Indeed, while we envisioned that the monastics would actually conduct these projects after the pilot workshop, their other obligations, our research and family obligations, and a lack of appropriate structures for us to support them from afar made this not feasible. Thus, any research training going forward must build a sustainable model for engaging monastics that accounts for these constraints.

CONCEPTUAL FRAMEWORK FOR RESEARCH TRAINING PROGRAM

We have four learning objectives for the Research Training Program (**Figure 2**). The first is to generate a sense of curiosity and excitement for research and the scientific process. This curiosity centers around an inquiry mindset (MacKenzie and Bathurst-Hunt, 2018), the concept that asking and answering questions are at the heart of research. The spirit of this inquiry mindset is nicely captured by Rachel Carson, who said "The aim of science is to discover and illuminate truth" (Lear, 1998). Thus, research is inspired by a systematic method of asking questions about the natural world, as is Buddhism. At its core, Buddhism is a set of practices and analytical methods for asking questions about mind and the fabric of reality (Dreyfus, 2003; Wallace, 2003). Although the methods may differ, the spirit of curiosity and inquiry are similar in science and Buddhism, which will be highlighted by the Research Training Program.

Our second objective is to introduce the monastics to scientific ways of inquiry and to help them become familiar with conducting research projects. There are three models for incorporating research into science education (Staub et al., 2016). The first is for instructors to design laboratory exercises that demonstrate phenomena or test hypotheses that have previously been tested. Numerous studies, however, have demonstrated that authentic research experiences, in which students conduct research to study questions for which the answer is not known, are more likely to increase students' interests in science and to bolster their identity as scientists (National Research Council, 2000; Gilardi and Lozza, 2009). Authentic research experiences can follow one of two inquiry approaches (Balgopal et al., 2017): directed (the instructor may come up with the experimental design) or guided (students develop their own experimental designs). In the second approach, instructors encourage students to define their own authentic research questions and to develop their own experiments, (open inquiry). The type of inquiry instruction that is, most appropriate for a particular group of students depends on the students' background knowledge and experience, as well as the instructors' ability to scaffold the research process. Below, we outline a 3-year training model to help monastics transition from a more guided research training experience to a less guided experience.

Our third objective is to begin to teach the monastics technical skills needed for research inquiry. Given the confluence between Buddhism and neuroscience, we will prioritize training in methods of cognitive neuroscience (e.g., EEG). Starting in years two and three, we will complement training in cognitive neuroscience with training in other methods commonly used in biology.

Our fourth, and final objective, is to continuously enhance the monastics' understanding of science and research. The Dalai Lama calls ETSI a hundred-year project, recognizing that it may take a long time to generate fully independent science curriculums and research initiatives. This insight provides a unique opportunity to teach about the slow arc of research, and the fact that it can take generations for theories to be fully developed and tested.

SPECIFICS OF RESEARCH TRAINING PROGRAM COURSE DESIGN

The 3-year sustainability phase of the ETSI program will involve an educational program where monastics will participate in both disciplinary studies and research training.

Year 1. Introduction to Scientific Ways of Inquiry and an Authentic Group Research Experience

In the first year of the Research Training Program, monastics will be introduced to the concept of the inquiry mindset, and participate in discussions about the shared spirit of curiosity and investigation in science and Buddhism. The monastics will be introduced to the research mindset and scientific process while developing a scientific vernacular in Tibetan, given that most monastics enter the program with little or no prior knowledge of English. The instructors will work closely with the translation team to generate a vocabulary of research terms in Tibetan, and to translate course and research materials from English into Tibetan.

There also will be live translation of lectures and workshops from English into Tibetan. The efforts of the translation team are truly historic, as there has never been, to the best of our knowledge, such an organized and systematic effort to translate scientific terms and concepts into another language.

Consistent with our commitment to experiential learning, a primary focus of year 1 will be for monastics to begin working on an authentic research project examining a question for which the answer is not known. In order to provide structure to the course, we will preselect this first research question and will guide the trainees through the process of designing and implementing a research project and testing hypotheses.

Our next objective for year 1 is to introduce the monastics to different methods for testing their hypotheses and conducting research, more generally. They will be introduced to experimental design and methods for collecting self-report (e.g., Qualtrics) and behavioral data, managing and tracking such data (e.g., Excel, Google docs), and scoring and processing data. We will also introduce monastics to methods used in cognitive neuroscience. We plan to build an electroencephalography (EEG) laboratory at the Drepung Loseling Meditation and Science Center and also purchase a number of mobile EEG systems, since these are frequently used to study human brain activity.

The COVID-19 pandemic and further reflection prompted us to envision a new model of how to make the training sustainable. To make this training and research development feasible, two of us (Nusslock, Gerardo) will work closely with Tibetan science educators who have advanced degrees in biology, physics, or neuroscience to develop the program. Together, we will establish a platform for continuous mentorship of the monastics. Over the year, we hope to foster several core characteristics of research, including collaboration and iteration.

Year 2. Data Analysis and Small Group Project Development

In the second year, research training will focus on data analysis and data presentation. We will use the data collected from the first-year research project for these training exercises. Monastics will learn how to generate descriptive data from their research projects and how to conduct introductory inferential statistics. Following analyses, we will introduce the monastics to strategies for visualizing and graphing their data, and giving scientific presentations.

Whereas the first-year research project will center on a preselected question, our goal for the second year is to help the monastics formulate their own research question and implement an experimental design. Depending on their interests, monastics may continue their training in cognitive neuroscience and learn intermediate EEG methods and be exposed to other methods. Alternatively, monastics will have the opportunity to switch their focus to other topic areas in biology or physics, depending on their interests. Monastics will work in small groups to carry out their second-year projects to benefit from each other's skills and to support one another. We will continue to support monastics in the second year as they implement their research projects.

Year 3. Setting the Foundation for Continued Research

In addition to continuing their training in data collection, analysis, visualization, and research methods, monastics will select a research topic in year three to specialize in. Our primary goal will be to help monastics set the foundation for continued research training beyond the sustainability phase. We anticipate that only a small group of monastics will want to move toward independent research, and our commitment will be to help these individuals pursue this goal and to become future leaders of research training for subsequent generations of monastics. For individuals interested in continuing their training in cognitive neuroscience, a select group will travel to the Affective and Clinical Neuroscience Laboratory at Northwestern University (Principal Investigator, RN) in the United States for in-depth training. The hope is that this training will set a precedence for collaborative research projects between monastics and academic scientists. We will also help monastics interested in specializing in other research topics or methods make connections with academic scientists beyond the ETSI program.

After the sustainability phase, the science instruction will shift entirely to the Tibetan monastic community, so they can continue to provide both coursework and support for research endeavors for monastics who did not participate in earlier ETSI programs. Monks and nuns will continue learning about the philosophy of science, biology, neuroscience, and physics, but their instructors will be from within their monastic universities.

CONCLUSION

The goal of the Research Training Program is to help actualize the Dalai Lama's vision of integrating scientific knowledge and the wisdom of Indo-Tibetan traditions to serve the best interests of humanity. ETSI reflects the first major change in the Tibetan monastic curriculum in six centuries, and through the Research Training Program, monks and nuns are learning the conceptual foundation of science, and the experimental and technical skills to carry out research projects. As educators in ETSI, we are as much the students as the teachers. Buddhism has a remarkably sophisticated understanding of reality, and both analytic and experiential methods for investigating reality that have been refined over millennia (Motokawa, 1989; Jinpa, 2016). Furthermore, the highest spiritual ideal in Tibetan Buddhism is compassion. Our view is that academic science would benefit from being guided by the principle of compassion, and a commitment to enhance the welfare and well-being of all sentient beings. Academic scientists can learn a lot from Tibetan Buddhism and His Holiness, in the pursuit of this ideal.

AUTHOR CONTRIBUTIONS

RN wrote the first draft of the manuscript and is Co-Director of the ETSI Research Training Program. NG wrote the section of the manuscript on the pilot program, was part of the pilot program team, and is Co-Director of the ETSI Research Training Program. JM was part of the pilot program team and edited the manuscript. JS was part of the pilot program team. MB was part of the pilot program research team and made substantial edits to the manuscript.

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Story, Metaphor, and Altruism in Cross-Cultural Teaching and Learning

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The Emory-Tibet Science Initiative (ETSI) is a cross-cultural exchange of Western and Tibetan Buddhist education and scholarship. In this partnership between the Dalai Lama Foundation and Emory University, two visiting Western scientists to Sera, Gaden, and Drepung Monasteries and two monastics who studied at Emory University reflect on their experiences teaching and learning from Western and Buddhist perspectives as part of the ETSI program. Specifically, authors explore the power of story, metaphor, and altruism in Buddhist and Western ways of teaching and learning. Authors consider the pedagogical similarities between (1) the variations of the Greek Method of Loci (Memory Palace) and the paintings and temple decorations found throughout Tibetan architecture and (2) the role of altruism and intrinsic motivation in learning outcomes. Current psychological and neurobiological evidence for the increased recall of episodic memories present in both Buddhist and Western use of story, metaphor, and intrinsic motivation associated with altruism will highlight the underlying principles that support these ancient methods. Finally, considerations on how each perspective informs the other is discussed, as well as practical suggestions for integrating methods across cultures.

Keywords: intrinsic motivation, curiosity, narrative, pedagogy, contemplative, Buddhism, Dalai Lama, science education

OPENING DEDICATION:

གང་གིས་ཐུགས་བརྩེ་ཉེར་བཟུང་ནས། །
ལྟ་བ་ཐམས་ཅད་སྤང་བའི་ཕྱིར། །
དམ་པའི་ཆོས་ནི་སྟོན་མཛད་པ། །
གཽ་ཏམ་དེ་ལ་ཕྱག་འཚལ་ལོ། །

I pay homage to Gautama Buddha,
Who, completely driven by compassion,
Taught sublime Dharma
To dispel all the wrong views.

རྩོམ་ཤོག་འདི་ཡི་དགོས་དོན་ནི། །
ཆོས་ཚན་ཁྲིད་ཐབས་བརྗེ་ལེན་དང་། །
མ་རིག་སེལ་དང་བྱམས་བརྩེ་དང་། །
འཛམ་གླིང་ཞི་བདེ་སྤེལ་ཕྱིར་རོ། །

The purpose of composing this article is to exchange teaching methods of Buddhism and science,
To clear away intellectual misconceptions and wrong views,
And to promote compassion and peace in the world.

INTRODUCTION

This article, framed by prayer elements of a traditional Tibetan debate, is a collaboration of Buddhist Monastic scholars and Western-trained neuroscientists, all members of the Emory-Tibet Science Initiative (ETSI). In these types of cross-cultural interactions, it is important to keep in mind Pratt (1991)'s contact zones and the negative effects of cultural appropriation. Rather than advocating political stances or telling others how to teach, the novelty of this reflection is the cross-cultural collaboration of ETSI authors to generate an appreciation for how mutual integration of pedagogical styles leads to a more holistic community of scholars. Indeed, ETSI is, "a unique educational endeavor, bringing together the best of the Western and Tibetan Buddhist intellectual traditions for their mutual enrichment and for the discovery of new knowledge" with programs to "explore the convergence of science and inner values in an effort to address humanity's greatest problems on more than a material level" (Emory-Tibet Science Initiative, 2021). Each author has invested time teaching and learning with both Tibetan Buddhist practitioners and Western scholars in their native and non-native institutions (Jangchup Choeling Nunnery, Sera Monastery, Emory University, and Georgia State University). This cross-cultural exchange has shaped our thinking and this contribution. Prior to our involvement in ETSI, we could not appreciate the many complementary aspects of Tibetan Buddhism and Western science. ETSI's cross-cultural exchanges have been far-reaching both intellectually and geographically, and we hope they have contributed to the timely vision of increasing kindness and compassion throughout the world. Thus, it is with tremendous gratitude that we pay our respects to His Holiness, The 14th Dalai Lama, and his successful effort to connect thousands of Buddhist scholars with scientists around the world. Our collaborative connection will reflect on comparative pedagogical methods that may shed light on the use of story and metaphor as a convergent principle observed both in early Western teaching traditions, dating back to the roots of Greek philosophy (Aristotle, ca. 350 B.C.E.; Yates, 1966), and ancient Tibetan Buddhist traditions. Despite the deep historic roots of these methods, current knowledge in neuroscience has only recently allowed us to begin to understand the neural underpinnings of story and metaphor as pedagogical methods. This paper describes an empirically-supported approach used by ETSI Scholars to integrate the use of story, metaphor, and altruism's intrinsic motivation to help others across Tibetan Buddhist studies and neuroscience education. This paper begins with story and metaphor and the neuroscience associated with these pedagogies and then focuses on internal motivation and altruism. Both Western and Tibetan scholars have benefited from their shared realizations about commonalities. The commonalities may have always existed, but through consideration and discussion, the four authors are now aware of them, see their utility more clearly, and can more intentionally use and emphasize them in future classrooms.

STORY IN TEACHING AND LEARNING

Entering a Buddhist temple, the Western neuroscientists among us were immediately awed by the wall-to-wall artwork. The neuroscientists did not fully understand just how many layers of meaning were embedded into each artistically rendered story. Similar to the early Greek Method of Loci (Memory Palace), a memory technique based on tying information to spatial locations, each intentionally placed piece of art serves as a mnemonic aid imbued with deeper cosmological lessons. The entrances of Tibetan Buddhist monasteries often feature a painting called the "Bhavacakra," or "Wheel of Life" (**Figure 1**). More than just a beautiful painting, the Bhavacakra depicts Yama, the god of death, holding a mirror up to a human at the moment of their death. The wheel within the mirror represents the nature of life, death, and rebirth according to one's Karma. These painted stories are used to teach the fundamental aspects of Buddhism and can be found in virtually all Tibetan Buddhist temples. Lay people will be able to describe simplistic concepts (e.g., the pig represents ignorance, the snake represents hatred, and the pigeon represents attachment), but monastic scholars derive far deeper and more complicated information from the same painting. For example, in the image, the snake emerges from the mouth of the pig. This artistic representation references deeper scriptural lessons wherein the root of anger comes out of ignorance. Additionally, the painting serves as a mnemonic device to study the many other sources of anger. Thus, the "Wheel of Life" takes on philosophical layers with each aspect of the painting available for deeper reflections. Buddhist Scholars will spend a lifetime connecting the artwork with scriptures and teachings. Could this phenomenal pedagogical tool inspire Western practitioners to adopt complex layered stories for teaching scientific concepts?

Like the "Wheel of Life," Western scientific graphs convey complex layers of information, telling a story with their data descriptions. As Western teaching content often involves physical phenomena, illustrations and videos help visualize and explain information. This media surpasses text descriptions in the ability to convey complexities and new knowledge, and so much digital media is readily available on the internet. The Tibetan monastics among us plan to integrate graphs, videos, and images into their teaching. A major concern within current Western pedagogy is overreliance on these videos and images rather than varying pedagogical techniques (Lang, 2020). These variations could include Eastern approaches and interactive uses of story and metaphor.

METAPHOR IN TEACHING AND LEARNING

Metaphor is seen in the Buddhist "Wheel of Life" as a daily practice as Buddhists enter the temple. The mirror held by Yama, the god of death, is a metaphor that serves as a reminder for self-reflection. The moon, which lies outside the mirror, is a metaphor representing the freedom of enlightenment in breaking out of the

FIGURE 1 | Bhavacakra (Wheel of Life). Held by Yama, the god of death, the wheel within the mirror represents the nature of life, death, and rebirth according to one's karma. Image provided with permission by Lobsang Dorje.

cycle of life and death. Thus, metaphors in Buddhist teaching are a key pedagogical tool.

The use of metaphor as a pedagogical tool in Western teaching can be traced back to the earliest Greek teachers, although the origin of their use is almost certainly earlier. Arguably, one of the most famous uses of metaphor is Plato's Cave (Plato Republic, 2009). Here Plato questions the nature of reality, contrasting the shadows cast onto a cave with the richer reality that awaits those philosophers pursuing the true nature of the universe.

ETSI Scholar Dr. Kazama has adapted the use of metaphors into an Introduction to Psychobiology and Cognition Course wherein the neuron becomes a multi-layered metaphor for life. In a more traditional introduction, neurons are brain cells that form neural networks found throughout the nervous system. Neurons use a process known as the "action potential" to send signals down the length of the cell. A relatively simple lecture on the basic properties of a neuron's action potential (**Figure 2**) can be taught through the strict lens of biology, physics, and chemistry (e.g., the structure of the neuron and the exchange of positive and negatively charged ions). However, such basic STEM lessons take on new vibrancy when other disciplines become integrated, and the neuron becomes a metaphor for life. Students are encouraged to derive deeper philosophical meaning as they are challenged to use the neuron's action potential as a fractal-like construct for human psychology. The individual neuron and its struggle between balance and growth are investigated as a microcosm for life. The "resting" phase takes on new significance as students realize that very little "rest" is occurring, rather that the neuron is constantly grinding to maintain its polarized state while being pulled toward electrical equilibrium. New intrinsic interest in the material is achieved when students visualize their own neurons pulled toward a balanced state but only achieving true balance for brief moments. This is much closer to a students' daily life, and students find solace knowing that every neuron in their head is built with that feature. Additionally, the properties of long-term potentiation (LTP), critical for forming memories, are given a multidisciplinary framework as ancient Greek mnemonic techniques (e.g., Memory Palace) and modern neuroscience insights about the strength of emotional memories [for review, see Hamann (2001)] complement the microscopic inner workings of a neural network undergoing LTP. Similar to the Tibetan Buddhist teachings where each moral lesson is represented through art and story, Simonides, described by Cicero as the creator of the Memory Palace, undergoes LTP as he rehearses the location of each family member buried in the palace's rubble (Cicero et al., 1942). While certainly a less complex lesson than the "Wheel of Life," the action potential has the ability to take on a multidisciplinary layered structure that is analogous to the pedagogical use of story and metaphor used in Tibetan Buddhist temples. This metaphorical approach has received very positive course reviews. More importantly, the modern application of this ancient methodology of metaphor has many qualities that have been empirically shown to increase student memory retention [for reviews on storytelling in STEM, see Klassen (2010) and Dahlstrom (2014)]. In addition to the memory benefits of the emotional content (Hamann, 2001), both the "Wheel of Life" and the example of the action potential lesson contain a first-person perspective. The "Wheel of Life" depicts a mirror held up to the viewer, and the neuroscience course relies heavily on introspection with each students' brain studying itself. While not taken as far as contemplative pedagogy (Zajonc, 2013), students are intrinsically motivated to learn the material and connect lessons in a multidisciplinary fashion through metaphorical pedagogy.

NEURAL UNDERPINNINGS FOR STORY AND METAPHOR IN TEACHING AND LEARNING

Both metaphor and story can enhance the emotional content of what is being learned by relating to the learner's existing framework of knowledge and to something that matters to the learner. Emotion strongly influences attention, an important early step in learning and memory (Tyng et al., 2017; Lang, 2020). Emotional memories are encoded and retrieved with involvement of the amygdala and medial temporal lobe structures (e.g., entorhinal and perirhinal cortex and hippocampus), as well as the putamen, insula, orbitofrontal cortex, and ventral visual stream [reviewed in Dahlgren et al. (2020)]. Other

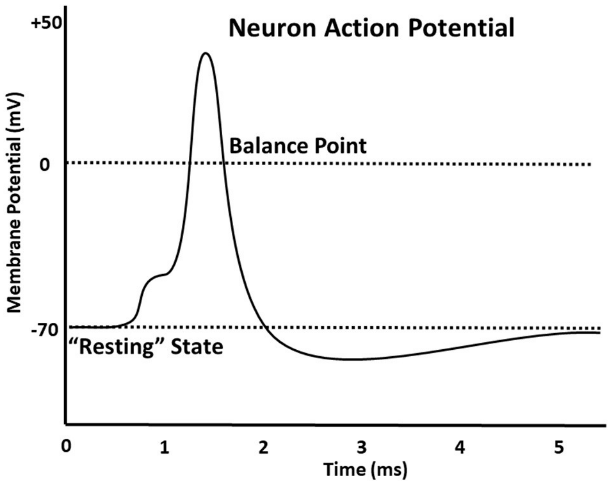

FIGURE 2 | Neuron action potential. Teaching graphic used to describe changes in the electrical balance of a stimulated neuron over time.

regions involved in emotional episodic memory retrieval are also involved in retrieval of emotional memory (e.g., dorsal frontal cortex) and episodic memories (e.g., angular gyrus; Dahlgren et al., 2020). Some of these same brain areas are involved in processing figurative language like metaphor. For instance, controlling for language complexity and compared to literal material, figurative language results in higher levels of activity in the anterior portion of the left hippocampus and the amygdala (particularly the left amygdala; Bohrn et al., 2012; Citron and Goldberg, 2014). Co-activation of the hippocampus and amygdala has also been associated with retrieval of emotional memories a year later (Dolcos et al., 2005).

The long-term memory of story components over the course of minutes correlates with coupling of activity in areas of the brain's default mode network, or DMN (Simony et al., 2016; review of the DMN: Raichle, 2015). With story, storyteller and listener show similar brain activity, including in areas of the DMN, and how well the areas couple correlates with comprehension of the story (Stephens et al., 2010; Silbert et al., 2014). For the same story, we see similar brain activity patterns for different individuals recalling the story, even if they differed in their native language the story was told in (Honey et al., 2012; Dehghani et al., 2017) or read text or watched a movie of the story instead of hearing it (Regev et al., 2013; Baldassano et al., 2017; Chen et al., 2017; Tikka et al., 2018; Wilson et al., 2018). Based on many research studies, Yeshurun et al. (2021) posit that over long timescales the DMN integrates new information from stories with prior knowledge.

INTRINSIC MOTIVATORS AND ALTRUISM

Like story and metaphor, intrinsic motivation is associated with enhanced memory and increased conceptual learning [reviewed by Ryan and Deci (2020)]. Classroom use of intrinsic motivation to increase memory and attention is not a new concept, but we want to reinvigorate the use of intrinsic motivation to balance heavy extrinsic motivation (e.g., grades) in Western teaching (Lang, 2020; Bain, 2021). In teaching, altruism's intrinsic motivation can be fostered by relating material to things learners care about, whether a story's protagonist, a family member, or a life passion. ETSI Scholar Dr. Black uses this idea in his Scientific Method in Neuroscience class. Students pick their own topics to critically evaluate the scientific literature. This autonomy is associated with enhanced student performance (Ryan and Deci, 2020). Whether their topic is video game effects on the brain or a family member's neurological disease, excited students dig more deeply into the topic than they would if it were an assigned topic. In Dr. Black's Neuroscience Laboratory, students test their hypotheses on small projects of their own design after learning techniques. The laboratory course culminates with a final project of a student group's conception and design. The students have autonomy and ownership by submitting their own proposal for approval and modification, conducting their experiment, and presenting it in a poster session to the full departmental faculty. Higher intrinsic motivation to learn generates higher activity in the midbrain and nucleus accumbens and enhanced memory (Gruber et al., 2014). The more memory is enhanced, the higher the anticipatory activity in the midbrain (substantia nigra/ventral tegmental area complex) and hippocampus and the greater the functional connectivity between them with intrinsic motivation (Gruber et al., 2014).

The importance of intrinsic motivation was reinforced for Dr. Black through the ETSI experience. The experience also inspired course incorporation of stories and studies of compassion in neuroscience as well as encouragement of students to select assignment topics to help a friend or family member. Students can have strong motivation for their projects when fueled by the altruistic goal of learning more about or helping someone they care about.

Altruism can also be fostered in scientific courses by human connection. In his very first undergraduate neuroscience course with his professor, Dr. Julio Ramirez, Dr. Kazama experienced this effect. The initial class exercise was a powerful visit to an Alzheimer's clinic to interview a patient with advanced Alzheimer's disease. Upon seeing the devastating effects of this neurodegenerative disorder, the altruistic motivation to help others was instantiated and remains a major driving factor over 20 years later.

In the Tibetan monastic tradition, virtually every dharma lesson begins and ends with prayers by the students and teacher to promote an altruistic intrinsic motivation for learning. Buddhists train to develop compassion and empathy, increasing altruism, and there is much to learn in that development for Western application. One example of Western application is cognitive-based compassion training (CBCT), collaboratively developed at Emory University and based on Indo-Tibetan Buddhist traditions (Ash et al., 2021). Following CBCT, students showed higher empathic accuracy and increased compassion (Mascaro et al., 2013, 2018). Greater compassion can increase altruism and the internal motivation to teach and learn.

CONCLUDING CROSS-CULTURAL INSIGHTS

Clearly Western science can benefit from shared aspects of Tibetan Buddhist pedagogy, but the reverse is also true. The scientific method is complementary to the logic-driven study and debate of scriptural texts by Buddhist scholars. ETSI Scholars Monk Kalden and Nun Thupten agree that focusing on hypothesis testing and empirical case studies will enhance their approach. They greatly appreciated the hands-on learning aspects of Western pedagogy with active collection and analysis of data to better understand the process of science and the scientific concepts under investigation. In most Tibetan monasteries, the most common form of learning is to memorize scriptures, read scriptural text, listen to scripture teachers, debate with classmates and teachers, and meditate. Monastics are already accustomed to using logic and reasoning to prove or disprove arguments, and this knowledge can be complemented by the scientific method, forming hypotheses and testing the hypotheses with experiments. Monk Kalden and Nun Thukten hope to implement active data collection and analysis, enabling students to build their own scientific stories.

Monk Kalden also plans to further foster student-led activities outside of the instructor-led classroom, motivating students to draw and take notes, encouraging group discussions and hands-on activities, and forming a WhatsApp or WeChat group to share notes, related videos, questions, metaphors, stories, and discussions on certain topics. These approaches further empower students and engage them in learning outside of class.

The ETSI partnership has been a unique educational endeavor. Both Eastern and Western scholars have benefited tremendously from immersing themselves in each other's educational systems and have been able to apply the pedagogical techniques described here to their own classrooms. In particular, the cross-cultural methods of story and metaphor are of benefit to students and enhance the interdisciplinary aspects of our respective fields. Of even greater importance, the central role of altruistic intentionality has been a major contribution by our Tibetan monastic colleagues. Supported by empirical data, the interdisciplinary nature of story, metaphor, and altruistic motivation provides multiple ways to access neuroscience for both Tibetan monastics and Western students alike. This will certainly lead to more effective and compassionate scholars, one of the major goals of ETSI. We close by again paying our respects to His Holiness, without whom this fruitful collaboration would not be possible.

DEDICATION:

བསོད་ནམས་འདི་ཡིས་ཐམས་ཅད་གཟིགས་པ་ཡི།
གོ་འཕང་ཐོབ་ནས་སྐྱོན་གྱི་དགྲ་བཏུལ་ཏེ།
ཀ་དང་ན་དང་འཆི་བའི་རླབས་འཁྲུག་པའི།
སྲིད་པའི་མཚོ་ལས་འགྲོ་བ་སྒྲོལ་བར་ཤོག །

Through this effort, May all attain enlightenment,
And by defeating the foe of negative emotions
May all beings be freed from the ocean of samsara (cyclic existence)
Which is ravaged by the waves of aging, sickness, and death.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

MB, AK, KG, and TD contributed to the ideas of the manuscript and wrote sections of the manuscript. MB and AK wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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