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# Montology: A Transformative Frame for the Future of Education About Mountains

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*Montology, the transdisciplinary science of mountains, applied to education incorporates several pedagogical approaches that could be used to energize the transformative change from sustainable to regenerative development from different perspectives. We include pedagogies with learning outcomes that apply 9 different educational methodologies, and we revisit them in the context of montology to focus on integrative, holistic mountainscapes as subjects of scholastic and nonscholastic educational initiatives. We discuss how these pedagogies must engage different stakeholders, including students from diverse backgrounds and disciplines. We conclude that the future of mountain education*

*relies on incorporating the new narrative of regenerative development, not only sustainable development, for the convergent science of mountain teaching and learning to be effective. This paper encourages educators to change paradigms to address the future agenda for education about mountains.*

**Keywords:** montology; sustainability education; mountain pedagogies; teaching modes; Andes.

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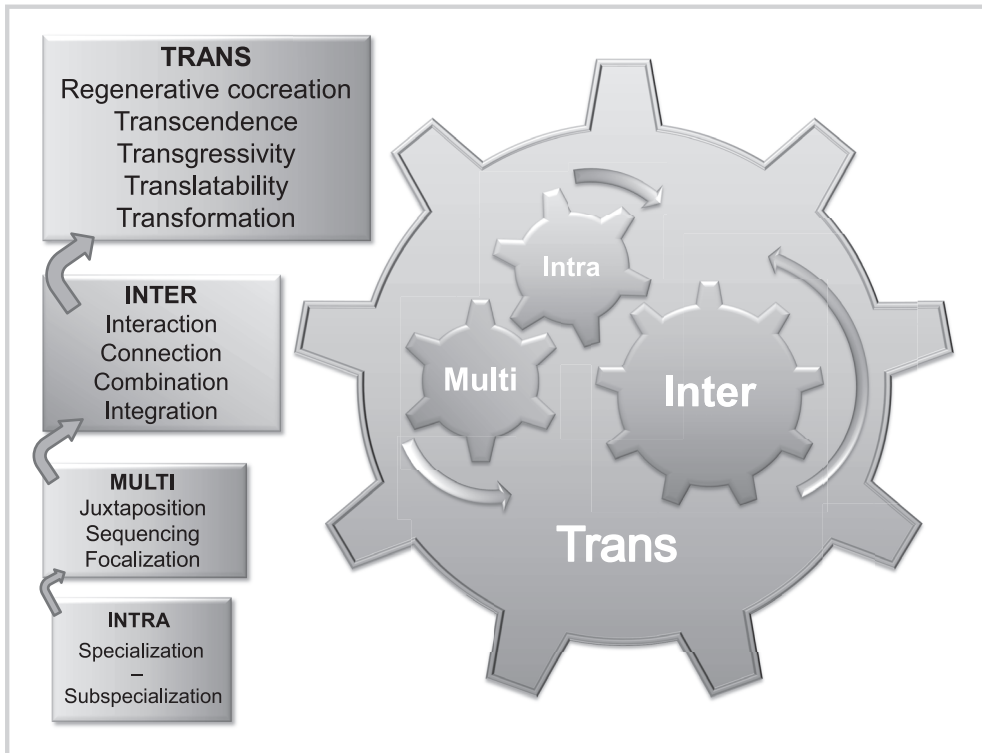
## Introduction

Here, we propose montology, the transdisciplinary science of mountains, as a framework to articulate the effort needed to overcome barriers to education about mountains, within the shift from sustainable to regenerative development. This article highlights the importance of montology in exposing students to the study of mountainscapes (the constructed reality of mountain entities). This not only encompasses the physicalities (geographical nuances of geomorphosites) and the spatialities (how space is converted into place) of social structures of mountain communities, but also the spiritual dimension of sacred sites and other cross-cutting views. Montology could therefore facilitate future convergent understanding of mountain themes and lead to practical applications for regenerative mountain development.

Since the Earth Summit gave them priority as fragile ecosystems, many advances have been made globally on education about mountains. Back in 1992, when the paradigm of biodiversity in pristine environments dictated conservation policy, it was fundamentally seen as an educational and research challenge (Bishop 2009). It reflected the advancement of geographical techniques to prevent further degradation of sloped terrain (Soffer 1982; Cajete 1994; Messerli and Bernbaum 2004; Somuncu 2006). Furthermore, advancing into the new century, higher education prioritized the internationalization of mountain conflicts, such as climate change and changes in biodiversity, and the direct relationship of deglaciated peaks, water supply availability, and food security issues (Smethurst 2000; Ray and Solem 2009; Samuel 2010).

Mountain education based on purely physical factors as drivers of the transformation of mountain sites then gave way to emphasis on socioecological landscapes (where social and ecological systems interact). This move appeared to be favored by planners and politicians who pushed for the incorporation of social sciences and technological applications into sustainability (maintenance of previously available resources) in the 21st century (Price et al 2004, 2013; Hanspach et al 2020), thus highlighting the needs of mountain education in comprehensive curricular offerings. With the popularization of geocritical narratives (a geographical angle on ecological literature and deconstruction of geosocial writing), the story of mountains, as a hinterland influenced by climate, has been completed. This encompasses the triad of (1) the contribution of manufactured landscapes (hybrid spaces where nature and culture interact), (2) the realization of the critical biogeography of mountains that have been transformed since antiquity, and (3) the need for a new framework for science and conservation (Debarbieux and Rudaz 2015). Thus, the pedagogical imperative for mountain sciences to converge resulted in montology, the transdisciplinary science of mountains (Sarmiento 2020a). Mountain studies and mountain geography relate to the different ways in which the theme is considered (Messerli and Ives 1997). This can be within a discipline (intradisciplinary), involving several distinct disciplines (multidisciplinary), combining several disciplines into a coherent whole (interdisciplinary) or transcending disciplines to create a new approach or convergent discipline (transdisciplinary) (Figure 1). Note that as we advance in mountain instruction, the jump in scale of intellectual tasks also changes from specialization toward generalization. Montology requires a cross-cutting

**FIGURE 1** Schematic representation of different approaches to education about mountains, following the cognition exerted by scale jumping from one cog to another within disciplines (intradisciplinary) to the contribution of 2 or more disciplines in a larger cog (multidisciplinary) that could lead to interaction and collaboration among disparate professional foci in a much larger cog (interdisciplinary) in the study of mountains. Montology emphasizes a cross-cutting approach across all disciplines engaged in the mountain theme, as well other nontraditional ways of knowing, such as art and the other humanities, religions, and myths (transdisciplinary). (Source: our own design)



approach that includes and integrates science, the arts and other branches of the humanities, and other ways of understanding mountains (Rhoades 1988). Mountain education has been positioned in the gap between physical and social sciences, as part of “environmental education” efforts, and can be incorporated into the general instruction of history, geography, natural sciences, and even experimental learning opportunities (Calabrese and Tan 2010). Mountain education has a range of barriers to incorporating sustainability education, namely conceptual, logistical, educational, and attitudinal (Templin 2013; Greenwell et al 2018). These are manifest in the most difficult topography of student mindscapes (their own internal landscapes or inscapes) (Sarmiento and Frolich 2012).

### Education for sustainable or regenerative development?

Educational targets must be aligned to the new paradigm of regenerative development (Lyle 1996; Muller 2020) to include options for self-organization, recreation, change, and restoration of the mountainscape (Hoxie et al 2012). Little progress has been made in 3 decades of attempts at “sustainable development,” that is, the maintenance over a long timescale of the tacit utilitarian benefits of natural systems to give “intergenerational” equity of “ecosystem services.” With the understanding that the only constant in nature is change, we envision that planners and educators should aim at a more plastic response to conservation of mountain systems. This involves incorporating actual

mountainscape dynamics, such as designing with the specific goal of renewal or recreating an improved mountain system as required by regenerative development (Mang and Reed 2012; Gibbons 2020). This is particularly important in social learning approaches for mountain-based disaster risk reduction (Alcántara 2004; Alcántara and Goudie 2010; Murti and Mathez-Stiefel 2018) and geomorphic factors related to environmental education (Reynard and Koratza 2016). Restoration of degraded slopelands is a priority for educational and political frameworks (McCann 2011; Gibbons et al 2018). Ancestral wisdom and alternative ways of knowing about mountains should also be integrated to complement these functional elements and produce an enriching, engaging, transformative mountainscape (Klein et al 2019). This emphasis on integration is evident in regenerative projects highlighting regional priorities (Frampton 1983) but has gained traction with the application of the transdisciplinary approaches to socioecological production landscapes and seascapes (SEPLS), as complex, adaptive systems (CASs). As such, it makes a key contribution to the transdisciplinary science of montology, bridging cultures, sciences, and mythologies associated with mountain epistemologies (Ban et al 2015; Sarmiento 2020b). This is now facilitated by internet and remote production of cross-disciplinary approaches to benefit mountain communities (Gabel 2019).

With the resurgence of an environmental education theme implicitly linked to mountains (Jeffrey and Riehl 1973), we think that mountain education for regenerative development is possible (Cole 2012). It can be achieved using pedagogical approaches such as “Time Machine,” “Crash Landing,” or



**FIGURE 2** Extracurricular activity for lifelong learning of visitors exploring the artisan craft of an Otavaleño's textile-making workshop and ecomuseum, in Peguche, Imbabura province, Ecuador. Sharing stories and life experiences linked to the mountainscape and its mythologies that regenerate local knowledge is a strong motivation of ethnotourism in the Andes. (Photo by César Cotacachi)



“Corporate Conscience,” each of which rely on traditional mountain geography. These lead to the implementation of the new pedagogical approaches presented below. The imperative of reducing barriers to environmental cognition is more crucial than ever (Ham et al 2010) with the internationalization of global education (Bishop 2009). We argue for broad application of the cross-cutting approach of montology (Sarmiento et al 2019) on behalf of a transdisciplinary wave that will educate the future citizens and denizens of mountain areas, maintaining ancestral and traditional ways of learning (Ball 2004; Ellis 2004; Wyndham 2010; Barreau et al 2019). We need to learn from failed attempts to achieve sustainability and integrate practical approaches of regenerative development. This will help to bridge the divides between the Global North and the Global South, between highland and the lowland ecoregions, between the education opportunities offered in schools versus home schooling, and between reductionist higher education and the holistic multiversities and practitioners of “real world” experience. We envision a montological framework that integrates different aspects of formal state education and private institutions, starting with young children and continuing to adulthood, in the so-called lifelong learning approaches to mountain cognition (Figure 2).

### Future agenda for mountain pedagogies

Previously, mountain geography was a matter of scholarly instruction at the undergraduate level in universities. Students were trained in traditional academic fields of earth science, geology, hydrology, and natural hazards (Messerli and Bernbaum 2004). Now, we know that montological approaches should be included for mountain cognition at all levels of formal and informal education. We envision that the convergent science of mountains will be offered not only in tertiary education, but also at the secondary and primary levels. This will be implemented with a variety of montological pedagogies using new technologies (Ige and Hlalele 2017). This trend has already started to take shape in school systems that follow unorthodox curricula, whereby the emphasis of learning-by-doing incorporates mountain instruction into

**FIGURE 3** Field trips, study abroad, and other learning opportunities for outdoor education should be included in the montology educator toolbox, so that the content is linked with direct experience, such as with the group of students visiting the *Imbakucha* sacred landscape, now Imbabura Geopark, in Ecuador. (Photo by Fausto Sarmiento)



K-12 levels (primary and secondary education), as well as field trips, guided visits, and other cocurricular and extracurricular activities (Figure 3). Some programs have gained prestige and popularity among professionals. These include the United Nations Food and Agriculture Organization's International Programme on Research and Training on Sustainable Management of Mountain Areas with its 2-week course on mountain management in Italy, as well as special training offered by the International Centre for Integrated Mountain Development in Nepal and the Consortium for Sustainable Development of the Andean Ecoregion in Peru. Many universities offer mountain-themed programs, such as Colorado State University in the United States, the University of Central Asia in Kyrgyzstan, and the University of Innsbruck in Austria. Programs are also being tested in unorthodox systems of higher education (Ji 2011) and practiced in institutions such as the Franciscan Multiversity in Uruguay, the Latin American Multiversity of Higher Studies in Mexico, the Indigenous Multiversity for Traditional Knowledge in highland Peru, and the Technical “Multiversity” of Twente in the Netherlands. An agenda-making plan is dependent on situated knowledge, institutional support, and political will; however, these trends should be incorporated if montological approaches are to be followed.

We envision that future pedagogies on mountain studies will emphasize different teaching techniques, away from the traditional face-to-face (F2F) classroom, into hybrid experiences of home/school, book/video, instructor/classmate, indoor/outdoor, and local/global interactions. Using mountains to exercise experiential learning should be mandatory (Mink and O'Steen 2003). Attempts to bridge the binaries of traditional education must be present in future pedagogies. This is particularly important now that distance education with printed materials has given way to sophisticated applications for mobile devices, computer-based tutorials, and massive open online courses. These are supported by educational software from private companies, such as Coursera, and textbook and eBook publishers. There is also the option of online instruction supported by school systems and internet providers, including D2L, Collaborate, Zoom, Go-to-Meeting, Google Slides, and Skype, among

others. The efficacy of these methods has been proven worldwide in 2020 while social distancing to reduce the incidence of COVID-19 meant a move away from traditional classroom settings. There are added bonuses for students: baccalaureate degrees can be obtained in half the time needed for F2F instruction, and online education packages can be delivered according to the student's own pace and budget. Furthermore, graduate degrees in mountain management are being offered in some universities, notably the University of Highlands and Islands in Perth, Scotland, home of the United Nations Educational, Scientific and Cultural Organization's (UNESCO) chair of sustainable mountain development; the Center for Mountain Research in Tsukuba University, Japan, which hosts the UNESCO chair of cultural heritage; and the newly created Center for Mountains at the University of Geneva, Switzerland. To promote this trend, we still need to find a publisher that produces eBooks in different languages to tackle the "mountain education challenge" with their own proprietary instructional software that includes the content and delivery of modern, appealing audiovisual materials adapted to local realities.

We also envision that in the future, the role of the montology teacher will be reinforced, not only by professionally trained educators, but also by experienced elders, tribal wisemen, shamans, the *Chipko* movement heirs, and the Council of Women Water Fighters, among others. The call of the first montologists (Frank Davidson and Jack Ives) "to find a respected scientist and environmental communicator to elicit public interest in mountains (just like Jacques Cousteau did for oceans, Edward Wilson for biodiversity or David Attenborough for nature)" is still relevant (Sunyer Martín 2020). It is important to remember that the success of the educational experience of each student starts with and is greatly influenced by what he/she has been exposed to at home and in their community. So mountain scholars should prepare educators that can assume mountain instruction from several didactic approaches (Figure 4), including professors that are ready to share their passion for mountains.

### Experiences: Teaching mountain geographies as montology

To motivate transdisciplinary interest, the Neotropical Montology Collaboratory of the Geography Department at the University of Georgia (UGA) offers a class "Mountain Geographies" (GEOG 3290) at the intermediate/advanced undergraduate level. The aim is to expose students to the transdisciplinary study of mountainscapes. This goes beyond geomorphosites and social structures of mountain communities, to include cross-cutting views of SEPLS from alternative dimensions, such as spiritual meaning, sacred mountain sites, and cultural ecosystem services. The syllabus is divided into areas of interest and blocks of 15 emphasized topics between "presses" (long-term influences) and "pulses" (ephemeral occurrences) factoring in mountainscape dynamics. Each class starts with a philosophical reflection on a famous mountain quotation that provokes discussion and elicits interest in discovering more information. Then, depending on the assigned theme of the class, a collection of different pedagogical approaches is utilized to offer a

**FIGURE 4** Oral traditions and storytelling are good ways to aid regenerative development by maintaining biocultural diversity and traditional practices of healing and other rituals associated with mountain livelihoods in the Otavalo valley, Ecuador. (Photo by César Cotacachi)



transdisciplinary ontology of mountain theories to ease the transition to regenerative development thinking. These include the following:

- The epistemology of mountains as a research theme;
- The geomorphology and physical properties of mountain CAS;
- The critical biogeography of mountain biocultural diversity;
- The geoecology of mountain societies, ecological risk, and vulnerability;
- The political ecology of water usage and climate change in orobiomes;
- Case studies of cultural landscapes in anthromes of mountains;
- Frontiers in ethnoecology research and mountain cultures;
- The intangible values of spiritual dimensions and sacred mountains;
- The urbanization of mountain cityscapes, amenity migration, and exurbation;
- The influence of globalization in transformed scenarios of mountain farmscapes; and
- Pathways for sustainable, regenerative mountain development in SEPLS.

Unlike the approach taken in mountain education in the last century (Cajete 1994), we follow the 9 approaches of alternative pedagogies offered by Menhart and Sarmiento (2010). This involves incorporating sessions where at least 2 methodologies become experiential in a single class, oriented to learning outcomes that integrate regenerative development thinking. They are selected from representative cultural milestones of education and are often followed by educators to empower students in specific areas of the educational process. The 9 possible permutations are listed in Table 1 and are explained below.

Most often in North America, the *lecturing methodology* of traditional teaching is combined with the *reflective methodology* of engaging in discussion following the new material with a question-and-answer (Q&A) process that generates further questions to debate. At UGA, we have taught effectively by



**TABLE 1** Pedagogical approaches to teaching mountain studies according to the target activity, learning outcome, and teaching mode and examples of suitable practical tasks. (Modified from Menhard and Sarmiento 2010)

Teaching method and mode <sup>a)</sup>	Main pedagogical style <sup>b)</sup>	Cultural reflection	Examples of practical use in and out of the classroom <sup>c)</sup>
Lecturing an attentive crowd	Lecturing	Recalling	Classroom lectures, memory, guest speakers, soliloquies
Questioning a naïve crowd	Debating	Inquisitive	Debates and discussions, contests, colloquia, symposia
Contemplating for a sensitive crowd	Inspiring	Sensitive	Poetry assignments, paintings, sculpting, music
Reading to an illiterate crowd	Reading	Bibliophile	Library searches, librarian talks, bookstore searches, calligraphy
Conjuring for a superstitious crowd	Wowing	Superstitious	Magic, tricks, prestidigitation, traveling
Telling parables for a religious crowd	Allegorical	Mystical	Fable reading, show and tell, biblical framing, ethics, morals
Conversing with a hungry crowd	Speaking	Entertainer	Avid conversations around a meal, feast, diversion
Exercising a tireless crowd	Sweating	Unrelenting	Effort and sweat equity in educational tasks, trial and error
Amusing a younger crowd	Invigorating	Humorous	Ancestral myths, song and dance, oral tradition, handcrafts

<sup>a)</sup>Based on face-to-face experiential learning with an identifiable group of lifelong learners.

<sup>b)</sup>Traditional practice of educational interaction to obtain learning outcomes.

<sup>c)</sup>Expanded in Table 3 with examples from Andean countries.

incorporating virtual Q&A sessions with mountain scholars who have diverse expertise and opinions from a range of locations. In some cases, the group organizes a meal at a local restaurant where the *speaking* or *deipnosophist methodology* is practiced while chatting about mountains, following the Roman tradition of healthy brains in healthy (and happy) bodies. In this way, students learn about mountain products with all their senses while sharing a meal and avid conversation. This often combines well with the *wowing methodology* of superstition and tricks to ignite the conversation even further. In other cases, we meet with the science librarian to adopt a *reading methodology*. This includes personalized group immersion in bibliographic research using the impressive library resources available and a primer bibliography of mountains (Resler and Sarmiento 2016). This often pairs well with the *sweating* or *elbow-grease methodology*, as the preparation of a research paper requires significant investment of time, energy, and enthusiasm in choosing and developing a theme, including bibliometrics and an extensive literature review, emphasizing sources where mountain geographers publish (Sarmiento and Butler 2011). As a reflection of the regional geography where UGA operates (within the Bible Belt in the Southeastern United States) students show much interest in using *allegorical methodology* of incorporating short parables with morals to be discussed in the biblical context of mountains framing both Old and New Testaments. This emphasizes the sacred dimension by applying the *invigorating methodology* of chants and oral history transmission from elders, shamans, or knowledge holders from tribal groups who could share (via remote links) directly with the engaged students in the classroom. We are also tempted to incorporate *inspiring methodology* when celebrating International Mountain Day on 11 December or Earth Day on 22 April by asking students to express their new connections with mountain themes through meditation, contemplation, poetry, painting, sculpture, or any other artistic form to bring humanistic flair to the scientific instruction about mountains.

## Experiences: Environmental education and Andean sustainability

Important advances have been made in environmental education in Latin America. Particular attention was placed on national campaigns to inform the public of all ages about the importance of mountain conservation (Sarmiento 1987) and its role in development (Debarbieux et al 2008; Barreau et al 2016). In this vein, many campaigns at the local level echo a trend that started in the Andean region with relative success, particularly for urbanites who have had little opportunity to learn about their backyard mountainscapes. In Ecuador, for instance, the Ministry of Education had contracted with consultants to develop a new statewide curriculum incorporating the tenets of ecology and conservation into different levels of scholastic instruction (Fundación Natura 1985). Successful campaigns using the nascent media attention that nature programming facilitated has also brought mountain education to a more prominent position. This can be seen in the observance of the International Year of Mountains (2002) and international fora, particularly the Triennial International Symposium on Sustainable Development in the Andes organized and convened by the Andean Mountains Association (AMA). It is also evident in books and journals articles (Sarmiento and Hidalgo 1999). However, little has been done to switch the emphasis of education models from sustainable development to regenerative development. Sustainability education has experienced tremendous gains, particularly associated with the “old 3Rs” (reduce, reuse, recycle) and Sustainable Development Goal 15 (protect, restore, and promote sustainable use of terrestrial ecosystems) (Sonetti et al 2019). Nevertheless, emphasis on technological approaches and on climate change requires a shift toward regenerative development, including an “old R” that was previously missing (rot) and applying the “new 3Rs” (respect, refrain, restitute).

An important contribution to improved knowledge of mountain education in the Andes was attempted at the

**TABLE 2** Examples of scholastic environmental education for sustainable development in mountains of South American countries included in the Andes Mountains. (Table extended on next page.)

Country	Example	Results and conclusions
Peru	The Aggregates Research Center of the National University of Agriculture of La Molina, together with partners from the Coordination of Science and Technology in the Andes—Piura (Andes of northern Peru), Apurímac (Andes of southern Peru), and Huánuco (Andes of central Peru)—have implemented a project called “Agrobiodiversity and traditional knowledge.”	The development of interactive learning techniques workshops helped foster a social-learning process. Participants were led through a set of creative exercises, discussions, visits, and interactions with local people. They were able to build a new collective understanding of the multiple dimensions of agrobiodiversity.
Bolivia	Through the Goteo Foundation, the “Flor de Montaña” Educational Community aims to operate an “alternative” school in Samaipata, Santa Cruz, that offers children and young people a comprehensive education based on a thorough understanding of themselves. The school is largely supported by the state, except for a little help from private individuals.	The education system applied follows the students in their search for knowledge, promoting artistic development and ecological sensitivity. Through harmonization rounds, sharing lunch, meditating at the beginning of the day, singing, and dancing, the children become aware of the importance of coexistence in community and collaborative work. They achieve an integral development of being, with awareness of the process.
Chile	The Pontifical Catholic University of Chile through the Center for Local Development and the Center for Indigenous and Intercultural Research proposed a procedural framework for the implementation of professional development opportunities for teachers in Early Education for Sustainable Development.	Education for sustainable development encompasses different fields (environmental, scientific, intercultural, citizenship, and community education), focused on skills, attitudes, and values rather than specific content knowledge.
Colombia	The Páramos project “Biodiversity and Water Resources in the Northern Andes Node Las Hermosas,” promoted by the Cauca Valley Corporation, the Alexander von Humboldt Institute and the European Union, and the Environmental Education Plan for high mountains in the Valle del Cauca.	From meetings with teachers and officials interested in this topic, the following agreements were made: (1) give voice to various actors and open community spaces to make decisions; (2) recognize local knowledge of the inhabitants of the high mountains; (3) include the practical experience of daily life as a learning subject; (4) contribute to solving problems in the territories; (5) strengthen the sense of leadership, identity, and roots in the territory.
Argentina	The National University of Tucumán, together with the “Education and Quality of Life” Foundation and the National Technological University, developed a “Water and environmental education in high mountains” program through a project with university volunteers on sustainability and improvement of the quality of life of the population of the mountains.	Socio-environmental problems in the Tafi valley, Tucumán, such as (1) water sources, quality, and availability for consumption; (2) the relationship between water intake and prevalent pathologies; and (3) the need to have indexes to evaluate the degree of conservation were tackled with educational content.
Venezuela	Venezuela pioneered Bilingual Environmental and Intercultural Education for Indigenous People, such as the Piaroa community of Gavilán. However, this program has basically the same design as the rural curriculum, despite the differing ethnic and environmental contexts.	The results of this study indicate that the educational process (bilingual ability and years of formal education) constitutes a social factor that contributes to the loss of traditional knowledge. Therefore, the current educational curriculum of the indigenous sector, and in particular the environmental education component, must be modified for the equitable integration of indigenous ethnoscience.
Ecuador	In the 1980s, the Ministry of Education and the Ministry of Agriculture of Ecuador launched a Program of Afforestation and Reforestation throughout the country. This program has focused on tree planting, under the modality of student participation.	The “Solitary Tree” project has been running for several years, and its main reference is the reforestation of the upper part of Casitahua, an extinct volcano located very close to Quito, on the equator. The project continues to be supported by the participation and involvement of different private and public entities and educational institutions that are concerned about the environment.

regional level with the establishment of annual post-graduate training courses at the Pan American Center for Geographic Research and Studies (CEPEIGE) with major support from the Pan American Institute of Geography and History (IPGH). Local scholars and foreign experts provided instruction in several areas of mountain geography, applied

projects, and field demonstrations in mountain areas around CEPEIGE headquarters in Quito, Ecuador.

The establishment of a research institute for the sustainability of the cloud forest of northeastern Peru (Instituto de Investigación para el Desarrollo Sustentable de Ceja de Selva, INDES-CES), at the National University

TABLE 2 Extended. (First part of Table 2 on previous page.)

Country	Year	Scale	Type	Audience size and type	Reference
Peru	2018	Regional	Formal	Thousands Teachers	Xu et al (2018)
Bolivia	2015	Local	Nonformal	Hundreds School children	“Flor de Montaña” Educational Community (nd)
Chile	2019	Local	Formal	Hundreds Indigenous teachers	Bascopé et al (2019)
Colombia	2018	Regional	Formal	Thousands Indigenous communities	Paredes et al (2018)
Argentina	2018	Local	Nonformal	Hundreds Neighbors	Rama Estudiantil IEEE Tucumán (nd)
Venezuela	2018	Local	Formal	Hundreds Indigenous teachers	Zent (2018)
Ecuador	2020	National	Formal	Hundreds School children	Fundación Sembrar Esperanza (2020) Ministerio del Ambiente and Ministerio de Educación y Cultura (2006)

Toribio Rodríguez de Mendoza in Chachapoyas, Amazonas, is notable. Several research projects dealing with food security and sovereignty of the nearby communities, who mainly produce coffee, cacao, rice, sugar cane, and cotton, have been implemented. INDES-CES has incorporated areas into these that deal with geospatial analysis, biodiversity

conservation, and applied genomic research for conservation. Often these projects include environmental education campaigns that help to disseminate findings and promote rapport with local communities. Timely assessments made with the stakeholders affirm a horizontal, participatory approach that fuses western technology with



**TABLE 3** Prospective activities to be implemented in the future according to the type of pedagogy established by Menhart and Sarmiento (2010). (Table continued on next page.)

Teaching mode	Alternative pedagogy	Proposed activities	Scholastic educational level
<b>Lecturing to an attentive crowd</b>	“Preaching to the choir” is appropriate to accentuate the theoretical foundations.	<ul style="list-style-type: none"> <li>Develop formal teaching and student learning processes in auditoriums and labs.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>Implement a comprehensive education program.</li> </ul>	High school
	Imparting terminology of mountain regenerative development.	<ul style="list-style-type: none"> <li>Hold conferences on what is involved in the study of mountains (montology).</li> </ul>	High school
		<ul style="list-style-type: none"> <li>Carry out environmental education awareness campaigns in strategic public places (highest capacity) in your city.</li> </ul>	High school
	“Do as I say” must be replaced with “Do as I do” for student engagement in sustainability practices.	<ul style="list-style-type: none"> <li>Integrate competences so that university students freely express their opinions.</li> </ul>	College
		<ul style="list-style-type: none"> <li>Conduct formative research to improve the process and quality of your learning.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>Hold fairs and exhibitions of images of flora, fauna, and ecosystem services of your town’s mountains.</li> </ul>	College
		<ul style="list-style-type: none"> <li>Host book fairs on sustainability and regenerative development.</li> </ul>	College
		<ul style="list-style-type: none"> <li>Organize public talks on climate change and the causes and effects on mountains.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>Encourage interdisciplinary socialization for the exchange of knowledge and/or intellectual, emotional, and social skills.</li> </ul>	College
		<ul style="list-style-type: none"> <li>Hold round tables to analyze of the correlation between architecture and people’s needs over time.</li> </ul>	High school College
<b>Questioning a naïve crowd</b>	Oxymoronic propositions should be debated using for and against argumentation.	<ul style="list-style-type: none"> <li>Develop colloquia at the intercollegiate level on issues of ethics and their influence on the sustainability of mountains.</li> </ul>	High school
	Question and answer sessions between subgroups should stimulate affirmation or rebuttal of sound principles of regenerative mountain development.	<ul style="list-style-type: none"> <li>Program discussions at the intersection and intergrade level on natural and human sciences of mountain geography.</li> </ul>	High school
		<ul style="list-style-type: none"> <li>Integrate evaluation skills into teaching to develop the students’ capacity for analysis and argumentation with debate topics focused on sustainable development in mountains with a comprehensive approach.</li> </ul>	High school College
	Social media should be used to engage in interactive campaigns of education and citizen science for biocultural diversity conservation.	<ul style="list-style-type: none"> <li>Hold a forum on local radio to promote citizen participation and free expression on biodiversity conservation issues.</li> </ul>	High school
		<ul style="list-style-type: none"> <li>Converse in public spaces about Sustainable Development Goals, in order to question the public and, if possible, propose innovative ideas about the goals.</li> </ul>	High school College
	Community participation and civic engagement should be included in local conservation programing.	<ul style="list-style-type: none"> <li>Host debates on anthropology and environmental economics in the mountains.</li> </ul>	College

TABLE 3 Continued. (First part of Table 3 on previous page; table continued on next page.)

Teaching mode	Alternative pedagogy	Proposed activities	Scholastic educational level
		<ul style="list-style-type: none"> <li>Facilitate public conversations about sustainable development initiatives in mountains of the region.</li> </ul>	College
		<ul style="list-style-type: none"> <li>Create an information exchange center and public debate space.</li> </ul>	High school College
<b>Contemplating for a sensitive crowd</b>		<ul style="list-style-type: none"> <li>Reinforce art education and/or artistic training.</li> </ul>	Preschool Primary
	Learning should be based on what you love instead of what you want.	<ul style="list-style-type: none"> <li>Exhibit works of art inspired by a love for nature and the importance of mountains.</li> </ul>	Primary High school
	Sensitize actions in favor of environmental protection.	<ul style="list-style-type: none"> <li>Hold a mural newspaper contest built with recyclable material and with themes of mountain geography.</li> </ul>	Primary High school
		<ul style="list-style-type: none"> <li>Encourage students to organize poetry recitals and literary fairs.</li> </ul>	Primary High school
	Highlight the need to use sensory stimuli to better understand science.	<ul style="list-style-type: none"> <li>Emphasize arithmetic and geometry.</li> </ul>	High school
	Skits could be presented in class on topics of current interest.	<ul style="list-style-type: none"> <li>Hold theatrical presentations of historical events in mountains with historical-cultural value.</li> </ul>	Primary High school
	Value handcrafted communication of regenerative development options.	<ul style="list-style-type: none"> <li>Implement identity markers with subjects based on 3 pillars of Andean philosophy.</li> </ul>	High school
		<ul style="list-style-type: none"> <li>Craft using recyclable solid waste.</li> </ul>	Primary
		<ul style="list-style-type: none"> <li>Hold a song festival with an ecological theme.</li> </ul>	Primary High school
<b>Reading to an illiterate crowd</b>	Reading and writing should be brought back as a focus of school achievement.	<ul style="list-style-type: none"> <li>Encourage collaboration between school boards and education departments to implement an environmental library.</li> </ul>	Primary High school
	A new genre of books with topical interest for cross-cutting analyses could be created.	<ul style="list-style-type: none"> <li>Hold contests to create comics about experiences in the mountains.</li> </ul>	Primary
		<ul style="list-style-type: none"> <li>Produce sustainable development trials in the Andes.</li> </ul>	High school College
	“Books on wheels” could bring literature to faraway places.	<ul style="list-style-type: none"> <li>Implement rural library creation campaigns with multidisciplinary bibliographic material.</li> </ul>	
	Bibliometric studies should elicit further reading on regenerative development.	<ul style="list-style-type: none"> <li>Hold fairs for reading fables and children’s stories about nature and the importance of its conservation.</li> </ul>	Preschool
		<ul style="list-style-type: none"> <li>Campaign to collect used bibliographic material.</li> </ul>	
	Exchange mechanisms for textbooks and environmental literature should be implemented.	<ul style="list-style-type: none"> <li>Hold review sessions on montology books.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>Produce academic essays on endogenous rural development.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>Organize training in bibliographic review techniques and tools and production of research papers.</li> </ul>	High school College
<b>Conjuring for a superstitious crowd</b>	“Guess where it is” game simulations could be used to highlight mountain geography.	<ul style="list-style-type: none"> <li>Create a sleight-of-hand game space to develop fine motor skills and artistic performance.</li> </ul>	Primary High school

TABLE 3 Continued. (First part of Table 3 on p A22; table continued on next page.)

Teaching mode	Alternative pedagogy	Proposed activities	Scholastic educational level
		<ul style="list-style-type: none"> <li>• Hold contests for creating fables and legends about sacred mountains.</li> </ul>	Primary High school
	Superstitious beliefs should be explained in the context of known scientific facts about mountains.	<ul style="list-style-type: none"> <li>• Give readings of science fiction that is set in the mountains.</li> </ul>	Preschool Primary
	“Environmental stochasticity” translated into the common sense of good luck in mountain communities.	<ul style="list-style-type: none"> <li>• Prepare and disseminate infographics on sustainable mountain development with a comprehensive approach.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>• Use educational materials such as triptychs, infographics, guides, brochures, booklets, and workbooks on sustainable development in mountains.</li> </ul>	Primary High school College
<b>Telling parables for a religious crowd</b>	“Route map” with achievable goals along the path to regenerative development should be constructed.	<ul style="list-style-type: none"> <li>• Develop environmental itineraries, complemented with didactic material to work around the parables.</li> </ul>	Primary High school College
	Fables that are easily grasped and understood should be used to present complex phenomena or ethical dilemmas.	<ul style="list-style-type: none"> <li>• Conduct guided outings to representative places in the area with historical, cultural, and/or environmental value.</li> </ul>	Primary High school
		<ul style="list-style-type: none"> <li>• Use radio fora as strategy to disseminate environmental education in the mountains to the population at large.</li> </ul>	High school
	Placing the common good above individual gains in the conception of needs-and-wants for sustainability.	<ul style="list-style-type: none"> <li>• Hold a fair for reading stories, parables, myths, and legends of the area, in public spaces.</li> </ul>	
		<ul style="list-style-type: none"> <li>• Participate in interviews in television programs about montology: its basic concepts and importance.</li> </ul>	College
	“Forgiveness as central value” could be used to correct past mistaken notions into new more inclusive and integrated educational alternatives.	<ul style="list-style-type: none"> <li>• Hold multidisciplinary round tables (involving peasants, indigenous people, and/or net residents of the community) on territorial opportunities and threats.</li> </ul>	College
		<ul style="list-style-type: none"> <li>• Develop academic subjects in the open air, in contact with nature.</li> </ul>	Primary High school
	“Respect the elder” and cultivate their wellbeing as wisdom holders should be emphasized.	<ul style="list-style-type: none"> <li>• Invite long-lived people from mountain communities to share their ancestral knowledge and lived experiences.</li> </ul>	Primary High school
	Higher powers and sacred mountain sites should be acknowledged as places to retire and meditate to gain epiphany or enlightenment.	<ul style="list-style-type: none"> <li>• Propose that promotional trips be in the form of community experiential ecotourism in the mountains to promote the local economy and the reevaluation of the traditions and history of these peoples.</li> </ul>	High school
<b>Conversing with a hungry crowd</b>	“Have fun” should be adopted as a principle in the learning process both inside and outside the classroom.	<ul style="list-style-type: none"> <li>• Carry out “sharing or picnics” in the field, promoting fellowship among the participants and contact with nature.</li> </ul>	Primary High school
	Food and drink could be brought to your educational outings and celebratory visits made that are associated with mountain values or with celebrations and ephemerides related to local civic and mythic lore.	<ul style="list-style-type: none"> <li>• Visit the mountain communities in order to get to know the lifestyle of their inhabitants up close, mainly on commemorative dates such as Earth Day, Water Day, Biodiversity Day, Environmental Education Day.</li> </ul>	High school College
	Use “happy moments” like social celebrations to highlight the need for regenerative development goals in mountain communities.	<ul style="list-style-type: none"> <li>• Guided visit to Protected Natural Areas of the community, so that the initiatives that are being developed by conservation are known.</li> </ul>	High school College

TABLE 3 Continued. (First part of Table 3 on p A22.)

Teaching mode	Alternative pedagogy	Proposed activities	Scholastic educational level
	“Al fresco” sessions of learning modules could feed both minds and mouths.	<ul style="list-style-type: none"> <li>Visit areas experiencing environmental problems in the community, in order to capture true data and evaluate changes over time, and consequently, their consequences.</li> </ul>	College
		<ul style="list-style-type: none"> <li>Hold communal themed fairs, where typical lunches of the culture are shared.</li> </ul>	
<b>Exercising a tireless crowd</b>	“Work hard” to learn, so learning is associated with effort and satisfaction in the work done.	<ul style="list-style-type: none"> <li>Hold conferences on the background of humanism inspired by the contributions of different cultures.</li> </ul>	College
	“Sweat equity” should be used to gauge educational performance.	<ul style="list-style-type: none"> <li>Promote organic farming for self-consumption and marketing.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>Implement reforestation initiatives for damaged forests with native species in the area.</li> </ul>	High school College
	Effective use of the new 3Rs: Respect, Restitution, Refrain.	<ul style="list-style-type: none"> <li>Formulate projects in recycling, gardening, and production of renewable energy.</li> </ul>	High school College
		<ul style="list-style-type: none"> <li>Prompt essay writing on the importance of mountain conservation and the role of the Sustainable Development Goals in this.</li> </ul>	High school College
	Incorporate homework-based practical outcomes, such as artistic renditions with practical applications.	<ul style="list-style-type: none"> <li>Recreate different structures of historical cultures in public spaces.</li> </ul>	High school
		<ul style="list-style-type: none"> <li>Conduct training in activities such as painting, ceramics, woodwork, and jewelry making, with ecofriendly approaches.</li> </ul>	Primary High school
		<ul style="list-style-type: none"> <li>Hold discussion days on sociology, ethnography, and humanism as part of the study of mountains.</li> </ul>	High school College
<b>Amusing a younger crowd</b>	“Listening to the mountains” is a special skill of montological approaches.	<ul style="list-style-type: none"> <li>Develop inclusive dance competitions and thematic dances or pow-wows.</li> </ul>	Preschool Primary High school
	Ancestral ways should be recovered to understand the murmur of the mountains.	<ul style="list-style-type: none"> <li>Hold songwriting contests inspired by love of nature.</li> </ul>	Primary High school
		<ul style="list-style-type: none"> <li>Develop singing festivals whose message leads to environmental awareness.</li> </ul>	Preschool Primary High school
	Dressing the part and showcasing valuable garb and original instruments could be employed when storytelling about local mountains.	<ul style="list-style-type: none"> <li>Create spaces for teaching spirituality and rootedness of local mountain communities, comparing distinct religious backgrounds that see mountains as the “abode of gods.”</li> </ul>	Primary High school
	The stage of debate should be shared with different audiences to reinforce the value of immaterial heritage and nonconsumptive values.	<ul style="list-style-type: none"> <li>Hold parades and exhibits of the customs and traditions of local communities such as food, clothing, economic activities, natural resources, and history.</li> </ul>	Preschool Primary High school

local knowledge. Examples of how environmental education programs have helped to establish mountain educational campaigns are given in Table 2.

## Discussion

Mountain education for sustainability should be reconsidered within the new framework of regenerative

development. This will create space for montological approaches, whereby local knowledge is hybridized with western science to address the tensions of biocultural diversity conservation in the global economy. Issues relating to the pressures of climate change must be addressed, as well as those arising from changes in religious, economic, investment, and military climates, among others. In shifting from sustainable to regenerative development, mountain



education should facilitate the recreation of models and reformulation of paradigms that work with situated knowledge in a global framework, a “glocal attitude.” Mountainous countries should design restoration ecology practices that support viable cashflows from SEPLS, away from the illicit economies of drug production and trafficking and damaging mining enterprises.

Unitarian (one-room-one-teacher) schools are common in some Andean countries. Here, a single schoolhouse caters to students from infants to teenagers, with 1 teacher visiting isolated mountain hamlets and remaining in each for 3 days per week (often Tuesdays, Wednesdays, and Thursdays). From many perspectives, this is impractical. These “unitarian schools” should be modernized to fit in an increasingly urbanized world (Tidball and Krasny 2010). Further, environmental education programs should be funded for both the citizens’ cityscapes in the mountains and students in community-conserved areas, which are often isolated and ill equipped.

Coronavirus disease 2019 (COVID-19) has changed expectations of future mountain sustainability in many ways. There is consensus among developers (Gonzalez 2021) that resource extraction could continue unchecked.

Consumerism and open market forces could continue to attack the agricultural frontier, expanding commodity production instead of conserving remnant forest landscapes. In this scenario, the protection of small areas that could serve as microrefugia of biocultural heritage is essential (Sarmiento et al 2020). Only with a more integrative and adaptive flux of information on mountain landscapes can we secure the future by regenerative development.

For this important change in mountain education, we propose activities that turn the tide of homogeneity and destruction toward a more appealing heterogeneous and constructivist mountainscape. Several examples of future mountain education activities for the school or out in the field are proposed in Table 3.

## Conclusion

We envision a future where montology is incorporated in the curricular offerings of both scholastic education and the nonscholastic options of popular and private systems of learning. The take-home message for educators is to open your mind to the new narratives of mountain lore and allow science, technology, engineering, the arts, and medicine (STEAM) to stimulate a new cadre of pupils who will be critical thinkers on mountain themes. We have collated a series of examples from the Andes Mountains whereby the prospective pedagogies of mountain education can bring significant gains in the learning outcomes of students. The take-home message for students is to be eager to learn from different pedagogical strategies, but always with the ability to integrate various objectives of personal and community involvement in mountain conservation. Montological approaches will help future montologists curve the predominant paradigm of reductionist sustainability science in mountain environments toward holistic regenerative development.

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