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Education for Sustainable Mountain Development: Preliminary Insights From a Web-based Survey of Opportunities

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This article provides insights from a survey of education programs for sustainable mountain development (ESMD) and comments on the findings from the perspective of United Nations Educational, Scientific and Cultural Organization's.(UNESCO) Education for Sustainable Development (ESD) for 2030 framework. Twenty-eight programs implemented by universities, research institutes, and nonprofit organizations (NPOs) are analyzed in terms of program structure, curriculum, and student needs and trajectories. Three-quarters of the programs are based in Europe and North America, the remainder in Central and East Asia and Australia. The programs fall into 6 categories, ranging from traditional university courses to summer schools, university collaborations, distance education, NPO-run skills-focused schools, and research facilities or observatories. Curriculum development toward ESMD has seen considerable progress, even if single-discipline and single-topic programs continue to be widespread. It has embraced fieldwork to offer learners hands-on experience and, increasingly, to work with local stakeholders in problem-oriented settings. Key elements of the ESD for 2030 framework are found, including concern for transformative learning and critical reflection on the structural causes of unsustainability. However, further research is needed to explore less visible aspects such as nonformal and informal education. Policy advocacy and institutional networking are required to scale up innovative approaches.

Keywords: *mountain education; sustainability; institution; sustainable development; web-based survey; higher education institutions.*

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Introduction

Learning and teaching about mountains has a long history. Educators engaged in mountain studies traditionally have a specialized grounding. Over the past 4 decades, however, this journal has confirmed the importance of reaching across disciplinary divides. Most mountain scientists also share a commitment to field-based studies and increasingly promote problem-oriented learning approaches. Mirroring educational developments elsewhere, mountain studies have begun to embrace distance education, bringing education closer to rural areas and livelihoods (Price and Rennie 2005). They have begun to explore transdisciplinary approaches (Balsiger 2015) as well as highlight the importance of integrating formal, nonformal, and informal education (Fritz et al 2017) and knowledge transformation and skills transfer (Phanchung 2019).

Today, the evolution of mountain studies is intimately linked to sustainable mountain development (SMD) agendas, which in turn are seeking expression through the 2030 Agenda and its Sustainable Development Goals (SDGs) (Wymann von Dach et al 2018). In parallel, education for sustainable development (ESD) has become a societal priority. In 2019, the United Nations Educational, Scientific and Cultural Organization (UNESCO) adopted the *ESD for 2030* framework with the overall objective of building "a more just and sustainable world through the achievement of the 17 SDGs" (UNESCO 2019a: 4). *ESD for 2030* is based on the 3 key notions of transformative action, structural changes, and the technological future. To give shape to these, the *ESD for 2030* framework identifies 5 priority action areas: (1) policy, (2) education and training settings, (3) educators, (4) youth, and (5) communities as the locus of action for sustainable development (UNESCO 2019a: 6).

The authors of this article have been working in the higher education sector, with a focus on mountain research and, more recently, teaching for more than 3 decades. In this article, we examine the multifaceted character of mountain studies posited by Bishop (2009) more than a decade ago. We provide preliminary insights from a survey of 28 mountain programs from around the world, highlighting their diversity in terms of structure, thematic focus, educational approaches, and student needs. We also identify a number of

opportunities and challenges that link mountain studies as education for SMD (ESMD) to the *ESD for 2030* framework.

Sources and methods

The programs were identified through 3 primary means. The starting point was the Mountain Education Database (Mountain Partnership 2020), which includes close to 170 programs; however, closer examination revealed that not all have a focus on mountains. We then cross-referenced the database entries with an Internet search for universities, institutes, courses, or nonprofit organizations (NPOs) using the terms "mountain," "alpine," and "education" in English. This identified additional programs. We did not use the search term "sustainable" because we knew that many ESMD-relevant programs do not use it in their title; we also excluded programs delivered by private individuals and companies. However, the search identified numerous institutions whose name included the term "mountain" or "alpine" but with no activities of obvious relevance to ESMD; these were excluded. For the same reason, we excluded programs closely related to mountain studies, such as ski area management, as well as mountain observatories or stations for specific research fields. Finally, we included a number of programs based on our involvement or familiarity or because they were identified in a workshop on ESMD at the 2019 International Mountain Conference in Innsbruck, Austria.

This approach has a number of limitations linked to language, information access, and generalization. First, because our Internet searches used English language terms, we generally missed programs taught in other languages. While we are aware of some such programs, for example in the Russian Federation, South America, and Africa, an estimate of their number is not possible. Second, because we relied on information available on the Internet, the sample is biased toward formal educational programs. Some of these may be linked to, or generate, nonformal or informal learning opportunities, but identifying these systematically was beyond the scope of our review (but see UNDP 2015). Finally, as the survey was based on a relatively small sample, any patterns identified did not necessarily apply to all mountain studies programs.

The final sample consisted of 28 programs (Table 1). For each, we collected information on the history, basic organization, target audience, institutional structure, educational methods, uniqueness of the subject, curriculum content, and linkages to other organizations. The resulting analysis is of a qualitative and exploratory, rather than a quantitative nature, designed to identify a number of links to the *ESD for 2030* framework and key issues for future in-depth research.

Types of ESMD programs

For the reasons mentioned earlier, almost three-quarters of the cases were based in Europe or North America; while the term "alpine" tended to be used in Europe, institutions or programs in the United States and Canada were more likely to use "mountains." The remaining programs were mainly based in East and Central Asia and Australia. These programs were primarily implemented by universities, research institutes, or NPOs, individually or in collaboration. The types of teaching and learning (TL) settings included regular oral lectures, online courses, and intensive lectures, often combined with fieldwork.

On the basis of these considerations, we inductively classified the 28 cases into 6 types (Table 1). These are not mutually exclusive but based on a particular distinguishing feature. For example, a summer school can be organized jointly by several institutions, or a university may offer a single module (part of a degree program or a specialized training course or standalone) through distance education. The types are as follows:

A. Degree programs, and specializations within a degree program, delivered by an individual university/college (A1–10);
B. Regular intensive courses, including a field component, such as summer or winter school (B1–6);
C. Single center organizing multiple relevant degrees and training courses (C1) or a degree program delivered by a group of universities (C2–3);
D. Online education programs or degree programs (D1–3);
E. Schools for environment conservation or outdoor education organized by an NPO (E1–2);
F. Research facilities (institutes) or observatories (F1–4).

Type A

Type A was the most frequent, accounting for almost one-third of the cases. Geography (eg A1, A4, and A5), forestry (A6, A8), and environmental sciences/management and engineering (A2, A9, and A10) are the main focal disciplines. Some institutions have multiple campuses offering a wide range of mountain-related courses. For example, Colorado Mountain College (A3) has 11 campuses in a region covering more than 30,000 square kilometers. Curricula in Type A programs are generally highly formalized, with the respective education institutions regulating the modules and the number and types of credits required to obtain a degree. Some programs specialized in a certain research field, for example, A8 in forest management, A5 in cryosphere research, and A3 in leadership education for outdoor activities. The scale of Type A programs varies considerably, ranging from an entire college to an individual classroom. Finally, some of these programs include service learning. An example is the "Mountain Resilience Corps Project" of Western Colorado University's School of Environment and Sustainability (A10), which requires students to complete a 600-hour project for a community organization anywhere in the world.

Type B

The distinguishing feature of Type B programs is an intensive learning experience lasting several weeks, often in the form of a summer/winter school hosted by a university or NPO. Most of the courses are organized in a specific mountain area and combine lectures by regular staff, presentations by invited speakers, and fieldwork; some led to an independent certificate, while others are organized as part of a degree program, such as the University of Geneva's Alpine Environment and Society field course in the Swiss Alps (B6), which is mandatory for master of environmental

TABLE 1 List of ESMD programs surveyed in 2018. [a)] (Table continued on next page.)

Type	Institution	Program	URL
A1	University of Montana, USA	Mountain Studies (undergraduate minor)	http://archive.umt.edu/catalog/18-19/colleges-schools-programs/humanities-sciences/geography/minor-mountain-studies/index.html
A2	University of Washington, USA	Mountain Hydrology Research	http://depts.washington.edu/mtnhydr/
A3	Colorado Mountain College, USA	Outdoor education programs	https://coloradomtn.edu/programs/outdoor-education/curriculum/
A4	University of Georgia, USA	Neotropical Montology Collaboratory	https://research.franklin.uga.edu/Montology/
A5	University of Sheffield, UK	Polar and Alpine Change (Department Of Geography)	https://www.sheffield.ac.uk/postgraduate/taught/courses/2020/polar-and-alpine-change-mscres
A6	Weihenstephan-Triesdorf University of Applied Sciences, Germany	Regional management in mountain areas	https://www.hswt.de/en/studies/degree-programmes/mrg.html
A7	University of Punjab, Pakistan	MSc in Mountain Conservation & Watershed Management	http://pu.edu.pk/program/show/900093/Centre-For-Integrated-Mountain-Research-CIMR
A8	University of Natural Resources and Life Sciences, Austria	MSc in Mountain Forestry	https://boku.ac.at/en/studienservices/studien/master-en/uh066429
A9	Shinsyu University, Japan	Environmental Sciences in Mountainous Areas	http://www.shinshu-u.ac.jp/graduate/interdisciplinary/english/course/me-science/e-sciences.html
A10	Western Colorado University, USA	Master in Environmental Management and Center of Mountain Transitions	https://www.western.edu/academics/school-graduate-studies/master-environmental-management-mem
B1	LabEx ITEM, France	Winter School	https://www.usi.ch/sites/default/files/storage/attachments/document/winter-school-labex-item-1.pdf
B2	University of Grenoble, France	Summer Program in Mountain Studies	https://www.univ-grenoble-alpes.fr/education/programs/short-programs-and-summer-schools/mountains-in-a-changing-world/mountains-in-a-changing-world-635414.kjsp?RH=1572013483445
B3	Scientific Network for the Caucasus Mountain region	Caucasus Sustainable Mountain Development Summer School	http://caucasus-mt.net/SNC-mt-Summer-School
B4	Mountain Partnership, UN/FAO, University of Turin, University of Tuscia	International Programme on Research on Mountain Areas (IPROMO) annual summer schools on the sustainable management of mountain areas	http://www.fao.org/mountain-partnership/our-work/capacitydevelopment/ipromo/en/
B5	Chinese Academy of Sciences, China	Third Pole Environment, Science & Technology Training	http://www.tpe.ac.cn/events/202001/t20200114_229427.html
B6	University of Geneva, Switzerland	Alpine Environment and Society (field course in the MSc of Environmental Sciences)	https://www.unige.ch/muse/master-environmental-sciences/
C1	UNIMONT (University of Milano, etc), Italy	Conservation and Sustainable Development of Mountain Areas	https://www.unimontagna.it/en/
C2	Tsukuba, Shinsyu, Yamanashi, Shizuoka Universities, Japan	Master Degree Program of Mountain Studies	http://www.msc.tsukuba.ac.jp/en/en-ms-degree-programs/
C3	Free University of Bozen-Bolzano, Italy; University of Innsbruck, Austria	Master in Environmental Management of Mountain Areas	https://www.uibk.ac.at/studium/angebot/ma-emma/index.html.en
D1	University of the Highlands and Islands, Perth College, UK	MSc in Sustainable Mountain Development	https://www.uhi.ac.uk/en/courses/msc-sustainable-mountain-development/

TABLE 1 Continued. (First part of Table 1 on previous page.)

Type	Institution	Program	URL
D2	University of Alberta, Canada	Mountains 101	https://www.ualberta.ca/admissions-programs/online-courses/mountains-101/index.html
D3	University of Geneva, Switzerland	Climate Change and Water in Mountains: A Global Concern	https://moocs.unige.ch/liste-de-cours/liste-des-cours-3/climate-change-water-mountains
E1	Mountain Studies Institute, USA	Experience Mountain Science Program	http://www.mountainstudies.org/programs
E2	Alpine School Campus, Victoria, Australia	School for student leadership	http://www.alpineschool.vic.edu.au/
F1	University of Colorado, USA	Institute of Arctic and Alpine Research	https://instaar.colorado.edu/
F2	University of Central Asia, Kyrgyzstan	Mountain Societies Research Institute	https://ucentralasia.org/Research/MSRI
F3	Vancouver Island University, Canada	Mount Arrowsmith Biosphere Region Research Institute (MABRRI)	https://research.viu.ca/mount-arrowsmith-biosphere-region-research-institute
F4	Chinese Academy of Science, China	Institute of Mountain Hazards and Environment	http://english.imde.cas.cn/

[a] Type A: Degree programs or specializations offered by an individual university or college; Type B: Intensive courses with field component such as summer or winter school; Type C: Single center offering multiple degrees or group of universities cooperating to deliver 1e degree; Type D: Online modules or degree programs; Type E: Schools organized by a nonprofit organization; Type F: Research facilities or observatories.

sciences students. A host university or institute may offer a course regularly, or a mountain research network such as Laboratory of Excellence for Mountain Innovation and Territory (LabEx ITEM) (B1) may coordinate the course on a rotational basis, with contributions from different universities in different years. Some institutes frame their program as a "training course," such as the Chinese Academy of Science Third Pole Environment offering (B5), but we identified few such programs. Many Type B courses are organized on an irregular basis but are open to the wider public, sometimes in the context of nonformal or informal learning through internships.

Type C

The Type C cases are characterized by collaboration between several institutions: UNIMONT–Università della Montagna (C1), a partnership of Milan University (lead role) with the Universities of Florence, Padua, and Turin; the master's degree in mountain science offered by 4 universities in Japan (C2); and the master's degree in environmental management of mountain area of the Universities of Bolzano and Innsbruck (C3). The TL settings are very similar to those of Type A programs, but the programs included lectures, experiments, and/or fieldwork strategically relevant to mountain studies; students seeking to obtain a degree must collect credits according to the home university's regulations. These programs are generally coordinated by a lead university (eg the University of Tsukuba for C2) or an umbrella organization (eg the University Centre of Excellence "Mountain University" for C1). In the latter case, coordination was initiated by relevant ministries. The geographical distribution of partner institutions is an important factor for assisting collaboration. For instance, the Free University of Bolzano and the University of Innsbruck are located 120 km apart in the Alps, which facilitates the sharing of observation/research fields and student exchange. The 4 universities in C2 are concentrated in central Japan, so they can share observation sites for field-based education. University collaboration is also a way to address educational competition through the establishment of complementary interdisciplinary study programs.

Type D

Type D cases are characterized by use of distance education: the University of the Highlands and Islands' MSc in sustainable mountain development (D1); the University of Alberta's massive open online course (MOOC) "Mountains 101" (D2); and the University of Geneva's MOOC "Climate Change and Water in Mountains: A Global Concern." This TL setting is particularly suited to providing interdisciplinary lectures and other learning materials to specialists and students in remote areas, such as mountain regions, or overseas. Online TL activities are also said to be cost-effective (eg Zhang and Worthington 2017), though this varies from case to case and has to be seen in the context of learning impact. Self-paced learning and independent homework are the basic TL style, but various degrees of direct communication among students or with lecturers have also been integrated in Type D programs, especially D1. Since distance education systems require advanced technology and instructors supported by their host universities (Volery and Lord 2015), online modules (eg D2, D3) are often offered as part of a formal degree program. Official approval of the credits and academic degrees delivered online thus depend on university regulations; for example, students of the "Mountains 101" MOOC (D2) only get credit if they are enrolled at the host university.

Type E

Type E programs derive from a regional organization for environment studies or conservation. They play a very important role in promoting and activating grassroots engagement and holistic views of social-ecological systems. For example, the Mountain Studies Institute (E1) promotes citizen science through volunteer opportunities, and the Alpine School Campus (E2) focuses on student leadership education through fieldwork in alpine environments. However, information about such programs is harder to find than for more formal ESMD programs, which points to the need for further study.

Type F

Type F programs are not implemented by educational institutions as such, but make crucial contributions to student education and training, especially at the graduate level. For example, the University of Central Asia's (UCA) Mountain Societies Research Institute (F2) identifies codevelopment and coteaching of UCA's academic programs among its 5 core objectives. Type F programs face major challenges as the cost of facility maintenance has forced many mountain observatories to close or be replaced by remote sensing observation (Adler et al 2018).

Characteristics of curriculum

The second theme of our analysis concerns the curriculum. Some elements were highlighted in the previous section, particularly the more formal programs (Types A, C, and D), where degrees or certificates are granted according to university regulations. However, we also noted the importance of nonformal and informal education as well as the growing but understudied trend of linking education to service learning for the benefit of local communities. The United Nation's Decade on ESD helped foster awareness of such practices, but the evaluation of the decade also found that institutional support is needed to scale up and maintain them (eg Buckler and Creech 2014). One such area concerns international collaboration on credit transfer systems and know-how, for example, as promoted in the Himalayan University Consortium (HUC 2020).

While mountain studies need to embrace cross-cutting concepts and diverse methods adapted to specific targets and fields, one major challenge is the difficulty of obtaining the necessary resources (facilities and staff): a reason why increasing the capacities of educators is a priority action area in the *ESD for 2030* framework. Mobilizing adequate financial resources for ESMD, especially where programs are implemented by individual institutions, remains another crucial challenge, as recognized in SDG 4. Institutional collaborations, such as Type C programs, are one solution to such challenges. Another is to use distance education, for example, Type D programs. Online teaching and learning delivery is particularly attractive compared with the construction of new fieldwork facilities; it also facilitates the involvement of qualified lecturers from anywhere in the world. However, distance education requires a significant degree of autonomy and discipline on the part of learners (Gillett-Swan 2017). Promoting direct and regular student exchange—important not only for peer learning but also for developing such sustainability competences as interpersonal and interprofessional skills, conflict resolution, and leadership (Wilhelm et al 2019)—in an online setting requires special attention to how technology mediates interaction (Sher 2009), as well as appropriate professional development for instructors (Kebritchi et al 2017). E-learning clearly provides unprecedented opportunities for learners previously unable to access quality education. Yet it can also create new inequalities, for instance with respect to individuals and communities suffering from energy vulnerability and poverty, or for learners unaccustomed to communication technologies.

Concentrating TL activities in intensive courses, such as summer schools (Type B), offers opportunities for curricular experimentation and development. The immersive environments thus created often constitute a fertile ground for transformative learning because students (and teachers) are in a setting that is very different from their usual daily routines. Students can directly exchange knowledge and work together to reflect on common experiences, while staff members can provide context-specific, research-based advice and guidance. The special circumstances of intensive courses (eg modest living quarters and shared resources) may lend themselves to another *ESD for 2030* objective: to "encourage learners to explore values which could provide an alternative to consumer societies, such as sufficiency, fairness and solidarity" (UNESCO 2019a: 11). Where TL activities involve interactions with mountain communities and stakeholders in problem-oriented settings, the same ethical issues that relate to transboundary research partnerships (Stöckli et al 2018) should be considered, for example, with regard to joint ownership of TL outputs and outcomes. Disadvantages of some Type B programs are that they can be costly, requiring a budget for travel and accommodation, and that the frequently tight schedule can lead to a very dense TL agenda, resulting in stress to both students and staff. One innovative approach to avoid this is to couple a summer school with an international conference, such as the 2019 International Mountain Conference. Nevertheless, it must be recognized that such activities involve high costs for travel and accommodation, so that targeted support for participants from developing countries may be required.

An additional trend in the surveyed programs is the inclusion of fieldwork (experiments) or internships to identify and analyze environmental problems in social-ecological systems. One approach is to use field sites designated by international organizations, such as Biosphere Reserves, Geoparks, or World Heritage sites, where education and research outcomes can be linked and contribute to international actions. For instance, Mount Arrowsmith Biosphere Region Research Institute (F3) uses the Mount Arrowsmith Biosphere Reserve as the educational setting for learning about international concepts. Such linkage approaches can provide an additional opportunity for project-based and problem-based learning, which has been recommended to promote student autonomy and collaboration (Kokotsaki et al 2016). Indeed, ESMD programs often seek to equip students for their professional careers or contribute to local governance, for example, by incorporating the perspectives of youth (eg A10) or focusing on social innovation for community resilience (Mathez-Stiefel and Murti 2014).

At present, many universities tend to use their own facilities in the mountains. When programs are delivered by multiple universities (eg C2), the location of fieldwork can change each year, so that the students and academic staff can experience different mountain environments and work with different stakeholders. To do so, field programs need to be well coordinated, and staff with different specialties need to accompany the students. Operating in multiple locations in turn underlines the importance of safety measures for fieldwork. Some programs, such as A3 and D2, train teaching staff in climbing skills or survival in cold environments, yet most university researchers are not professionals in outdoor sports, and financial/insurance support from the universities is often a challenge. Where climate change impacts fieldwork safety (eg glaciology methods in B6), returning to the same location only every few years can change the risk profile of a TL setting.

A final trend and challenge related to the ESMD curriculum relates to the complementarity (or trade-off) between local context and globally shared concerns. While it is understandable that local students and staff are primarily interested in (or want to focus exclusively on) "their own" mountains, many ongoing problems are similar across different mountain ranges because of the globalization of both human activities and human-induced global environmental change (eg Klein et al 2019). To address local–global links systematically in education programs requires including both local and global experiences in TL settings. Several programs address this in their curricula. For instance, Mountain Studies at the University of Montana (A1) includes 2 submodules within a core module (global issue): regionally specific mountain studies and general mountain studies. In the master of mountain science in Japan (C2), students first follow an intensive course on global and fundamental mountain sciences, then proceed to study specific topics in the local/specific contexts at their home university. In the master in environmental management of mountain areas (C3), students spend the first semester in Italy and the second semester in Austria. Through the Center for Mountain Transitions (A10), students get a chance to engage in projects worldwide.

Education for sustainable development and students' needs

Priority Action Area 2 of UNESCO's *ESD for 2030* framework addresses education and training settings, with a particular emphasis on a whole-institution approach and cooperation between education institutions and host communities (UNESCO 2014). In this section, we address the notion of lifelong learning in the broader community (of study and work) from the perspective of student needs and expectations. This notion has 2 elements. First, the concept of lifelong learning suggests that ESMD programs are only 1 phase in the long-term learning project from childhood to adult life. As a consequence, such programs ought to pay attention to what awaits students after graduation and equip them accordingly. Second, lifelong learning in communities suggests that measuring the impact of TL activities ought to include whether students acquire the capacity to become change agents in the "social and cultural milieu of the community" and its political and economic governance structures (UNESCO 2019b: 11). Graduates from successful ESMD programs should be able to go on to contribute to the achievement of all 17 SDGs.

Lifelong learning also requires attention to specialized and transversal knowledge and skills, a combination at the heart of SMD (Blanchard 2013). ESD itself recognizes the articulation between different fields of knowledge: environment, energy, disasters, biodiversity, climate change, international understanding, world heritage, local culture, among others (Parker 2010). Programs B3, B4, C1, and D1 embrace this by explicitly including "sustainable development" in the program title. Many of the other programs include key fields such as biodiversity, disaster risk reduction, and climate change in the names of program descriptions or specific courses. By contrast, terms or concepts related to international understanding or cultural matters are clearly underrepresented in program and course descriptions. In general, it is fair to say that while the social sciences have come to occupy a stronger position in ESMD curricula, inclusion of the humanities and arts continues to be weak—although this may be an artifact of our research approach, which did not identify programs such as those of the Department of Appalachian Studies at East Tennessee State University (2020).

Equipping ESMD students to become change agents means empowering them to think critically about the relationship between economic growth and sustainable development. In assessing this relationship, they need to understand the dynamics of natural and social processes and awareness that managing or conserving social-ecological systems in the mountains must not be limited to a logic of control. Many of the programs in our survey include elements that suggest such knowledge. Beside the term "development," many also use "management" (eg of forests, water, or deer) and "conservation" (eg of "rare species" or "local culture"). The use of these terms indicates that these are crucial issues for SMD and suggests that they respond to a demand by learners and the communities in which they may later come to be active. At the same time, our changing world demands that ESMD evolves. In Japan, for instance, recent extreme winter weather caused avalanches. When a school training group was affected by one, various questions ensued: Was the teacher or the weather forecaster responsible for the accident; should learning under extreme conditions stop so as to avoid all accident risk; or—by contrast—was this precisely the kind of training future generations need?

Despite these difficult questions, the general direction ESMD ought to take is relatively clear. Whether such a direction responds to student ambitions, however, also needs to be considered in curriculum design, especially from the perspective of lifelong learning. From the authors' experience, 2 somewhat different career trajectories may be identified. The first, involving graduation with a degree in a specific field related to mountain studies, points to programs under Types A, C, and D because these are known (or assumed) to lead to a job with an employer with corresponding staff needs, as is being explored in the project AlpJobs (2020). This trajectory is typically followed by undergraduate students wishing to continue their original specialization in Type A programs. The second type of trajectory, often seen in mature students with work experience, involves the desire to gain general knowledge

about mountain issues. They may thus prefer to study crosscutting issues because they want to gain additional knowledge and skills to pursue particular business opportunities or extend management activities in the mountains. For this trajectory, Type B or E programs may provide suitable opportunities. To promote truly interdisciplinary study with innovative ideas, Type C or D programs may be appropriate. Overall, as there is little comprehensive and comparative information that potential students can use to guide their ESMD program choice, many tend to join a program close to where they live; though some benefit from distance learning possibilities (Type D).

Future perspectives

Can education contribute to SMD? Does it? Based on a survey of 28 ESMD programs, we tentatively suggest a positive answer to both questions. In each of the 6 types of programs we identified, efforts to contribute to SMD are clearly identifiable. Indeed, even if the term "sustainability" appears in few program titles, most of them are relevant to SMD, have made great strides in establishing interdisciplinary (or at least pluridisciplinary) curricula, and incorporated knowledge transfer approaches, at times aligned with transdisciplinary research. Although much more in-depth study is needed, these programs contain many elements of the *ESD for 2030* framework;, if not directly, then through the teaching and learning settings they embrace and promote.

Yet there is much more to do, especially in the areas of curriculum design, communication methods, and the concept of fieldwork. Curricula have become more interdisciplinary, but the arts and humanities continue to be underrepresented. As mountain people have diverse levels of education and backgrounds, and many are located in remote areas, communication methods in ESMD need to be examined with consideration of learning tools and online methods using multiple languages. Fieldwork is recognized as a crucial ingredient but often requires infrastructure that is costly to maintain. Where ESMD programs have begun to embrace transdisciplinary approaches, TL activities involving local stakeholders should adhere to the same collaborative principles that apply to research.

The *ESD for 2030* notions of transformative action, structural changes, and the technological future serve as useful guidance for ESMD development. For example, transformative learning is more likely to happen where programs include problem-oriented, field-based studies (Balsiger et al 2017); structural changes linked to unsustainability tend to be revealed where curricula are interdisciplinary and based on holistic views of social-ecological systems (Sterling 2001); and (some) technological advances are (naturally) captured through distance learning.

Additionally, most *ESD for 2030* priority action areas are also relevant for ESMD: particularly policy, educators, and community. There is a great need to learn more about existing and emerging ESMD programs and the people who participate in these programs. Establishing networks of education in the spirit of lifelong learning to enable the resilience of mountain communities is a necessary corollary. Global and regional organizations and initiatives, such as the Mountain Research Initiative, the Himalayan University Consortium, and the Network for European Mountain Research, can play an important role, not only in establishing inventories of lesser-known programs and raising awareness of ESMD at international conferences but also in advocating for ESMD policy in the context of SDG 4.

Ultimately, the *ESD for 2030* framework promotes a type of learning environment where context-specific knowledge and skills are based on fundamental values of global citizenship education. SMD in general and ESMD in particular have embraced a similar view, based on the diversity of mountain environments and societies. ESMD programs recognize that, while some knowledge and skills are transferable, local and regional contexts are very important. As mountain environments and societies change, demand for ESMD will also evolve. As a result, tracking ESMD programs and promoting policies that are supportive of ESD is of increasing importance.

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