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Expanding Formal School Curricula to Foster Action Competence in Sustainable Development: A Proposed Free-Choice Project-Based Learning Curriculum

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Abstract: A key determinant and outcome of successful environmental education is 'pro-environmental behavior', i.e., behavior that involves conscious action to mitigate adverse environmental impacts at personal or community level, e.g., reducing resource consumption and waste generation, avoiding toxic substances, and organizing community awareness initiatives. However, some theorists have sought to move away from rationalist models of behavioral modification, towards holistic pedagogical initiatives that seek to develop action competence. In light of the global push towards achievement of the Sustainable Development Goals (SDGs), emerging evidence suggests that education initiatives should foster action competence so students may be equipped to contribute to sustainable development as part of their education. The UNESCO Education for Sustainable Development (ESD) Roadmap 2030 has also identified key priority areas to strengthen ESD in formal curricula. This article reports two informal environmental education initiatives for promoting action competence and pro-environmental behaviors in school-aged children. The authors recommend that formal education settings (e.g., schools) should incorporate self-directed, free-choice project-based learning to augment environmental education programs and promote students' action competence for contribution to attainment of SDGs. To this end, we propose a Free-Choice Project-based Learning for Action Competence in Sustainable Development (ACiSD) Curriculum, comprising six implementation dimensions, namely: (1) project duration and teaming arrangements, (2) topic selection, (3) student support, (4) teacher support, (5) learning environments, and (6) digital access and equity. For each implementation dimension, we recommend action steps to help educators implement this curriculum in their own educational settings, with the aid of an illustrative worked example.

Keywords: action competence; pro-environmental behaviors; informal learning; project-based learning; ecojustice; environmental and social justice; sustainable development goals (SDGs); action competence in sustainable development; free-choice learning

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1. Introduction

The first internationally recognized definition of *environmental education* was drafted by W. B. Stapp of the University of Michigan [1] (p. 33), as fostering citizens who are "knowledgeable concerning their biophysical environment and associated problems, aware of how they can help to solve these problems, and motivated to work towards effective solutions". The concept that knowledge leads to awareness and action has been a pervasive thread in subsequent developments in the field. The central objectives introduced at the first Intergovernmental Conference on Environmental Education in 1977 have provided a firm foundation in this regard. Convened by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Program (UNEP), the Conference membership sought to form consensus on the role of education

in addressing environmental problems, and establish strategies for the development of environmental education supported by regional and international cooperation [2].

The Conference established interdisciplinarity as a key tenet of environmental education, with a focus on understanding and leveraging the interactions between biological, physical, social, economic, and cultural factors that influence environmental problems. One of the guiding principles of environmental education, as defined by the Conference, is the utilization of formal and informal learning environments and educational approaches, with an emphasis on personal experience and real-world application [2,3]. Critically, these principles are integral for building a sense of values, contributing to the preservation and betterment of the environment, and providing for the well-being of future generations [2]. Still, despite this sweeping codification, there remains a lack of consensus among educators and researchers as to what pedagogical approaches and initiatives may be most effective in promoting impactful environmental education [4,5].

Furthermore, in light of the increasing recognition of the interconnectedness between environmental and social issues, as depicted by the United Nation's Sustainable Development Goals (SDGs), it is no longer useful to consider education of environmental issues in isolation of the broader socio-economic context [6]. The *2030 Agenda for Sustainable Development* and its underlying 17 SDGs are rooted in the knowledge that social issues, such as poverty, health, education, and economic growth, must be tackled concurrently with environmental issues, such as climate change, ocean health, and animal welfare [6]. UNESCO has developed the *Education for Sustainable Development (ESD) Roadmap 2030*, whose vision is to "build a more just and sustainable world through strengthening ESD and contributing to the achievement of all 17 SDGs" [7] (p. 54). ESD's priority action areas include: advancement of policy, transformation of learning environments, capacity building of educators, empowerment and mobilization of youth, and acceleration of local level actions. Furthermore, the *ESD 2030 Roadmap* aims to advance the achievement of the 17 SDGs with a special focus on technological advancement [7].

A key challenge in the framing of environmental education historically has been the complex and evolving nature of attributes associated with the framing of environmental education initiatives. In this paper, we focus on three key attributes, namely, pro-environmental behavior, action competence, and educational technologies. First, we present the notion of 'pro-environmental behavior', which has traditionally been a focus of environmental education programs, and discuss the challenges associated with characterizing this concept. Subsequently, we argue that 'action competence' is a better pursuit for formal and informal environmental education initiatives, particularly when considering the shift away from environmental education as an isolated discipline towards more holistic goals of ESD. Additionally, given the *ESD 2030 Roadmap*'s focus on technological advancement, we also present the case for educational technologies and blended pedagogy, and their potential role in augmenting ESD.

2. Literature Review

2.1. Pro-Environmental Behavior

Pro-environmental behavior, i.e., behavior that involves conscious action to mitigate adverse environmental impacts, has long been considered a key determinant and outcome of successful environmental education. Pro-environmental behavior can be conducted at personal and/or community level, e.g., reducing one's resource consumption and waste generation, avoiding toxic substances, organizing community awareness initiatives [8–10]. Certain altruistic values, such as caring for animals and the natural environment, and considering the wellbeing of other people, are often applied when explaining pro-environmental behaviors [11]. Pro-environmental behaviors have also been closely associated with measures of subjective and social well-being [12]. However, there is no single, globally accepted definition of pro-environmental behavior [5,8]. Indeed, considerable time has been devoted to investigating the underlying mechanisms and factors associated with pro-environmental attitudes and behaviors. In a timeline of developments,

numerous researchers have addressed various parameters, of which a selected few are highlighted as follows.

Hines et al. conducted a meta-analysis of the available literature at the time, and found that knowledge of issues and action strategies, an internal locus of control, pro-environmental attitudes, a willingness to verbally commit, and a high level of personal responsibility were positively correlated with pro-environmental behavior [13]. Bamberg and Möser [14] have since replicated and extended the analysis by Hines et al. [13], also finding that moral norms were a significant predictor of behavioral change. These findings are somewhat reinforced by Allen and Ferrand [15] who investigated the importance of altruistic-personality dimensions on pro-environmental behavior, finding that personal control and sympathy were significant correlates. Wider influences are profiled in Blake [16] who calls for the inclusion of individual, social, and institutional barriers in models of pro-environmental behavior. Chawla [17] conducted a phenomenological investigation of the connection between environmental sensitivity and the choice to enter conservation-related careers. Chawla found that formative experiences in nature during childhood, membership in pro-environmental organizations, pro-environmental family values, formal education, and mentorship were commonly reported motivations [17]. Pinder et al. [18] later also suggest that conservation-career preferences were related to childhood preferences for nature-related books, movies, and school subjects, environmental volunteering, as well as biospheric family values.

Mayer and Frantz [19] assessed the validity and reliability of the connectedness to nature scale, and argued that it is an important predictor of pro-environmental behavior. White et al. [20] developed a framework represented by the acronym SHIFT which proposes that consumers are more inclined to engage in pro-environmental behaviors when the message or context leverages certain psychological factors, namely Social Influence, Habit Formation, Individual Self, Feelings and Cognition, and Tangibility.

While such a breadth of examples can provide a basis for measurability and empirical investigation, some have argued that the development of a comprehensive model of pro-environmental attitudes and behaviors is likely not possible, or even useful, due to the inherent complexity and number of factors involved [5,8]. There are many competing and even complementary models describing pro-environmental behavior. However, the complex interaction effects and wide array of context-influencing internal factors (e.g., personality traits, environmental knowledge, and value systems) and external factors (e.g., infrastructure, politics, and socio-economic standing) have so far impeded efforts to produce a comprehensive unifying model of pro-environmental behavior [8]. Indeed, some theorists have sought to move away from rationalist models of behavioral modification towards holistic pedagogical initiatives that seek to develop action competence [21]. The notion of action competence is further discussed in the following section.

2.2. Action Competence

Some researchers argue that the purpose of education should extend past the mere promotion of knowledge and attitudes to supporting learners in taking tangible action [22–24]. Indeed, Chawla [23] notes that promoting action should be a key purpose of education. Originally envisioned by Jensen and Schnack [25], the action competence is defined as the capacity to engage in responsible acts and counteractions for a more compassionate world, and is built upon the foundations of democratic participation, reflection, critical thinking, and incomplete knowledge [21,25]. While the concept of 'action competence' has been defined and utilized in different educational disciplines, the primary goal of such an approach in the context of environmental education is to empower students with the necessary knowledge and skills to make environmentally sound decisions. For example, formal and informal pedagogical initiatives that are action-centered may include ecojustice-based programs [25,26], environmental-leadership programs [27], and community-based sustainability programs [27]. A case study of one such community-based environmental leadership program which promotes hands-on action competence will be provided in this article.

Sass et al. [22] explore the concept of action competence in the context of education for sustainable development, namely Action Competence in Sustainable Development (ACiSD), and seek to characterize the individual 'action' and 'competence' components of the broader action-competence framework. 'Action' is different from 'behavior' in that it is driven by the actor, with a specific intention to address an issue. The issue at hand may be seen differently by people with differing views on how to solve it. Thus, action competence requires people to make well-considered and purposeful decisions about which action they wish to undertake [22]. Under the action-competence approach, the action itself is decided upon by students themselves, and not dictated by educators.

Traditionally, 'competence' has been the viewed as the ability to apply knowledge and skills towards performing a specific task or job that is often delineated by another person. However, 'competence' in the context of this framework goes beyond this somewhat limited definition and seeks to empower individuals to think critically and take charge [22]. Additionally, it should be noted that in action competence, competence can be viewed as both an individual and a collective phenomenon. Thus, problems are often approached in a pluralistic and democratic way, with consideration of diverse perspectives and values. An action-competent individual is also able to consider the SDG at hand, and view it holistically amid broader socio-cultural, environmental, and economic contexts. Furthermore, a key tenet of ACiSD is the notion of 'language of possibility'. While action competence requires critical thinking, this skill must be complemented by values of "possibility, courage, and inspiration" [22] (p. 297). An SDG action-competent individual is a visionary, and is able to maintain optimism about the potential for positive change.

2.3. Informal Environmental Education and Action Competence

Informal environmental education occurs outside of mainstream educational institutions. Examples include programs provided by non-profits and community-based organizations, zoos, museums, and forest schools. Importantly, most environmental education around the world is not acquired within the formal classroom, but outside the school, via free-choice informal learning [28]. This is not surprising, given that formal educational institutions are often limited in their ability to provide more comprehensive environmental education programming to students due to a variety of reasons, including pressure to focus on mandated curricular areas, limited school and family resources, or simply a lack of knowledge [29].

However, authors, such as Falk [28], have argued that while informal learning is valuable, it should not be solely relied on, for the promotion of action competence in younger generations. Indeed, Falk posits that learning is "rarely an instantaneous event, but rather a time consuming, cumulative process" [28] (p. 269). Therefore, the guiding principles of informal environmental learning should be incorporated within formalized school curricula. Levinson's [30] advocacy on bridging the civic-empowerment gap in the education sector is a case in point of the above recommendation. Levinson quotes the Civic Mission of Schools, which states that civic education should help young people acquire and learn to use the skills, knowledge, and attitudes that will prepare them to be competent and responsible citizens throughout their lives [30,31].

2.4. Educational Technologies

The ESD Roadmap 2030, as described previously, has established 'technological advances and ESD' as a key thematic-focus area. This thematic area seeks to harness existing and emerging technologies for sustainable development education [7]. Educational technologies and blended pedagogies are being increasingly used in environmental education to support action-oriented approaches by providing students with a more diverse range of knowledges, contexts, and experiences to aid in making environmental decisions and taking responsible actions [32]. The use of digital technologies, such as websites, digital games, and mobile applications, can for example, aid in solving environmental problems, supporting the process of environmental awareness, and promoting nature connectedness [33–35].

Such approaches may also draw on emerging and immersive technologies, such as virtual reality (VR) and augmented reality (AR), which have been shown to promote learning achievement [36], problem solving [37], motivation to learn [38], communication [38], pro-environmental attitudes or behaviors [39], and action competence [40]. VR and AR can enhance outdoor and classroom-based learning through interactive overlays or models, allowing students to visualize and interact with objects or processes that would normally remain 'invisible' to them due to their scale or the timeframe over which they occur [41]. Further, VR can provide students access to locations they could not otherwise explore due to barriers such as distance, safety, disability, or a lack of resources [32]. A growing convergence of game-based approaches with VR and AR technologies is additionally providing new opportunities for various immersive exploration and action-oriented learning paradigms [42]. Generally, such technologies have the potential to provide scaffolding across formal and informal environmental education programming, providing digital spaces in which educators can bridge classroom and community-based learning [42]. A case study of one such technologically enhanced educational program will be provided in this paper.

3. Research Aim

As outlined above, environmental education initiatives often pursue the promotion of pro-environmental behaviors and/or action competence, and are increasingly being supported by educational technologies and blended approaches to learning. Informal environmental initiatives, offered by outdoor camps and education programs run by not-for-profits, have also become important resources for educators and families.

However, there is now a need for reimagining global formal education structures to incorporate environmental learning to a greater degree [43]. A UNESCO [44] (p. 3) review of educational curricula around the world identified that "45% of national education documents studied made little-to-no reference to environmental themes". This UNESO [44] review recommends that ESD be integrated in formal curricula with a holistic pedagogy that engages students in action-oriented learning. Varela-Losada et al. [21] (p. 414) acknowledge that it is currently not possible for us to fully understand what problems future generations will be faced; and thus: "The only thing that can be done from the school is to set the bases for their future action; that is, to be in charge of the development of competences that can help them make sustainable decisions in a democratic way."

Therefore, in this investigation, we examine two informal learning programs with the aim to understand: "How can formal school curricula be enhanced to foster children and youth who are action competent in sustainable development?"

4. Methods

The purpose of our exploration is to generate a multi-faceted understanding of environmental education in its real-life context and propose transferrable applications for strengthening environmental education within formal school curricula. To this end, two case studies are examined in this paper, both of which are set within informal pedagogical settings, and seek to promote pro-environmental behaviors and action competence in children and youth through varied means, including self-directed and technologically enhanced learning.

For this exploration, we adopted a hybrid version of the Generic Inductive Qualitative Case Study Approach, as described by Liu [45]. This approach is considered useful for descriptive and exploratory research in education, as it allows researchers to borrow from variety of methodological traditions, such as phenomenology (to understand lived experience), or grounded theory (to develop a model or theory from emergent findings) [45]. Case studies are chosen in a purposive manner, and can be contingent, a priori, or demographic. Furthermore, the chosen case studies can be based on the "researchers' decision regarding what kind of participants would contribute appropriate data" [45] (p. 131). Thus, this

methodology enabled us to analyze and compare two pre-selected cases and generate recommendations for enhancement of formal curricula as per our research aim.

The first case study explores primatologist and environmental activist, Dr Jane Goodall's youth education program: Roots & Shoots (R&S). Authors (BH, MK) have been associated with the R&S Australia program in voluntary (BH, MK) and formal employment (BH) capacities for over five (BH) and ten (MK) years respectively. The authors consider the R&S model an action-oriented ESD approach, which enables learners to choose their preferred SDG/socio-environmental issue, devise solutions, and offer purposeful action at both individual and collective levels—a process that resonates deeply with Sass et al.'s [22] ACiSD framing. In the R&S model, learners proactively choose and conduct their actions. With appropriate supports from mentors and educators, they are then able to create change for their chosen cause, while developing transferable skills to help address other SDGs through future initiatives.

The second case study engages with the development of Camosun Bog 360 (CB360) by the author (MJ): a virtual field trip of a wetland called Camosun Bog, located in Vancouver, Canada. CB360 uses virtual reality to encourage students to explore Camosun Bog while connecting them to learning materials developed by a broad network of knowledgeable others, including Indigenous communities, non-profit organizations, and local land managers. In line with the goals of ACiSD, CB360 seeks to democratize the learning process through the incorporation of multiple world-views and perspectives, while encouraging students to take part in community-based initiatives to restore and protect the bog for future generations.

Data analysis in this study focuses on the generation of themes through a comparative analysis of case studies; the aim is to develop emergent themes or categories into a framework or model [45]. Notably, upon generating themes from the presented case studies, we elected to identify existing pedagogical models within which to situate our study's emergent findings. The reason behind this choice was the research team's wish to generate knowledge that is amenable for rapid translation into educational practice, given the global urgency to promote ESD and help achieve the SDGs. The creation of a new pedagogical model would mean additional work and effort required in evaluation, demonstration of benefit, and subsequent translation.

After a review of existing pedagogical frameworks, we identified Kokotsaki et al.'s [46] project-based learning as a suitable vehicle through which to translate our recommendations into formula curricula. This combination of inductive thematic analysis, followed by a deductive application of findings into an existing pedagogical framework is an example of 'abduction', as described by Thornberg [47] (p. 249): "an interplay between the observation of derails, and background theories". This abductive approach to qualitative data analysis is compatible with Liu's [45] theoretically flexible case study approach and allows researchers to work in a cyclical manner between the research question, data gathering, and analysis. It is inherently iterative and becomes progressively focused over the duration of the research process.

A summary of the context and pedagogical features of the two case studies is provided in Table 1. Subsequently, each of the case studies is described in relation to their potential to promote action competence for sustainable development with supporting perspectives on pedagogical foundations and opportunities for enhancement of environmental education in formal school curricula.

Table 1. Summary of Case Studies.

Case Study	Roots & Shoots (Australia)	Camosun Bog 360
Context	A youth-service program founded in 1991 by Dr Jane Goodall DBE. The Roots and Shoots program is active in Australia and nearly 60 countries worldwide.	A self-directed, virtual field trip of a local wetland, Camosun Bog, situated in Vancouver, Canada. The virtual field trip can be accessed using a desktop, mobile device, or virtual headset.

Table 1. *Cont.*

Case Study	Roots & Shoots (Australia)	Camosun Bog 360
URL	https://rootsandshoots.org.au	https://mikejerowsky.com/camosun-bog-360/
Audience/ Participants	Children, young people, and families	Primary-school children and families
Learning Objectives	To foster respect and compassion for all living things, to promote understanding of all cultures and beliefs, and to inspire each individual to take action to make the world a better place for animals, people, and the environment (APE).	To promote action competence in students through the development of connection to nature, ecological literacy, and pro-environmental behavior.
Related SDGs	SDG 4: Quality Education SDG12: Responsible Consumption and Production SDG13: Climate Action SDG14: Life below Water SDG15: Life on Land SDG17: Partnerships for the Goals	SDG 4: Quality Education SDG 11: Sustainable cities and communities SDG13: Climate Action SDG14: Life below Water SDG15: Life on Land SDG17: Partnerships for the Goals
Related ESD Roadmap Action areas	Transforming learning environments Building capacities of educators Empowering and mobilizing youth Accelerating local-level actions	Transforming learning environments Building capacities of educators Empowering and mobilizing youth Accelerating local-level actions
Pedagogical foundations	Integrated STEAM (science, technology, engineering, the arts, and mathematics) approach Experiential learning Reflective learning	Connectivist framework Experiential learning Reflective learning
Learning Direction	Self-directed projects	Self-directed learning
Pedagogical support	Project mentoring, peer-led youth leadership programs	Physical and virtual learning support through materials provided by civic, community partnerships.
Educational technologies	Internet/Websites, social media, digital media (e.g., videos)	Internet and web, digital media, virtual reality, and augmented reality applications
Outcomes	Local, accessible social impact projects within a local school, community and/or natural environment.	Informal learning opportunities to engage students with socio-environmental issues in a reflective, age-appropriate way, that highlights broader systems of oppression and environmental justice.
Resources	Online toolkits, teacher resources, environmental-literacy resources produced in partnership with Indigenous authors, communities, and partner organizations.	Online educational materials accessed using virtual hotspots in Camosun Bog 360. Resources have been co-produced with land managers and community volunteers and integrate learning materials developed by Indigenous authors.
Funding	Jane Goodall Institute Philanthropic/government body funding	Social Sciences and Humanities Research Council of Canada.

5. Case Studies

5.1. Case Study 1: Roots & Shoots (Australia)

Jane Goodall's Roots & Shoots Australia is the domestic program arm of the Jane Goodall Institute Australia. Founded in 1991 by Dr Jane Goodall DBE and active across approximately 60 countries worldwide, this youth service program equips children, youth, and families to foster respect and compassion for all living things, to promote understanding of all cultures and beliefs, and to inspire each individual to take action to make the world a better place for animals, people, and the environment (APE). Specifically, support is provided to young leaders through individual project mentoring, peer-led youth-leadership

programs, grassroots community grants programs and the provision of free environmental literacy resources produced in partnership with Indigenous authors, communities, and partner organizations across Australia.

Connecting more than 4000 individual schools, community groups, education centers, and individuals across Australia alone, Roots & Shoots (R&S) fosters youth-led impact primarily through supporting self-directed projects designed, implemented, and evaluated by youth and their educators, within a local, intergenerational community of practice. The pedagogical foundations of the programs are situated within an Integrated STEAM approach that reflects the widely adopted and critiqued BSCS 5E Instructional Model as espoused by Bybee et al. [48] and Eisenkraft [49].

Throughout their project experiences, students are guided through a process of community mapping, and supported to select a local issue that directly impacts their immediate environment. Next, they design a project or solution to address the issue; one that supports their engagement with local stakeholders, wildlife, and ecosystems through a strength-based approach that reflects their interests and values. Finally, they complete their project with the support of their local community and the R&S mentoring network.

The aims associated with these youth-led projects may include one or more SDGs. Examples of projects include, but are not limited to: raising peer-led environmental awareness through developing a school-wide recycling program (SDG12: Responsible Consumption and Production), activating the local community through organizing community beach clean-ups (SDG14: Life below Water, SDG17: Partnerships for the Goals), mobilizing peers or local community in tree-planting or habitat-restoration works (SDG13: Climate Action, SDG15: Life on Land, SDG17: Partnerships for the Goals). Finally, youth are guided to evaluate and reflexively examine their impact to consolidate project learning in the presence of their informal educators and Roots & Shoots mentors. The aim of the learning experience is to grow youth members' action competence, supported by experiential learning, improved nature connectedness, and a supportive intergenerational community of practice.

The importance of childhood socio-cultural experiences in predicting pro-environmental concern and behavior continues to establish itself within the literature [50]. Indeed, just as Dr. Jane Goodall's advocacy continues to focus upon the compounded environmental benefit of actions that reflect the interconnectedness of animals, people and the environment, so do pro-environmental concerns and behaviors appear to be best supported by learning experiences that integrate not only animals and local ecosystems, but also feature an intergenerational community of practice, featuring community members of diverse ages modeling pro-environmental behaviors in the presence of young members [18]. Such communities of practice appear to be particularly vital in supporting youth members to articulate how their values integrate with their environmental actions, and in doing so, may build youth members' sense of agency in response to social and environmental justice [14,27].

Ultimately, the nature of seed-funded community projects, such as those supported within Roots & Shoots Australia's community grant programs, are indeed inherently limited in scope and scale, if financial capital alone is responsible for predicting improved action competence in youth members. Fortunately, what appears in evaluative reflections captured by youth participants is their focus upon experiential learning, i.e., local, accessible projects within their local community and environment, and often immediate/near-immediate tangible impact of their efforts (e.g., new vegetation in a formerly empty parcel of land).

Finally, youth members regularly acknowledge the role of social capital as exemplified in a community of practice: a local, supportive, and intergenerational group of leaders that provide knowledge, support, and acknowledgement to youth, guiding them to articulate their values, define an issue of interest, identify a project-based solution, and consolidate learning through guided reflection.

5.2. Case Study 2: The Development of Camosun Bog 360

Camosun Bog 360 [51] is a self-directed, virtual field trip of Camosun Bog (the Bog), in Vancouver, Canada and was designed for use by primary school children. Camosun Bog is

located in Pacific Spirit Regional Park, on the unceded, ancestral territory of the Musqueam people for whom it has been a source of stories, food, medicines, raw materials and trade commodities since time immemorial. The Bog has been significantly impacted by climate change and local housing developments. Its continued survival relies on the restoration and monitoring efforts of the Pacific Spirit Park Society (PSPS) and Camosun Bog Restoration Group (CBRG) who work alongside local land managers at Metro Vancouver Regional Parks (MVRP), the Musqueam Indian Band (MIB), and community volunteers.

This virtual field trip uses interconnected 360° 4K video spheres, which provide students with the illusion of being placed at stationary points along the Camosun Bog Boardwalk. Camosun Bog 360 can be accessed using a desktop/laptop computer, mobile device, or a variety of virtual headsets ranging from Google Cardboard to the Meta Quest series. Educational materials are accessed using virtual hotspots that connect to learning materials on local flora and fauna, volunteer restoration efforts, the importance of Camosun Bog to the Musqueam people, and its colonial history.

In terms of the pedagogical foundations that guided the creation of Camosun Bog 360, Jerowsky drew on critical experiential and connectivist frameworks, with the end goal being to promote action competence in students through the development of a personal connection to nature, ecological literacy, and pro-environmental behavior. Broadly, experientialists argue that students construct knowledge through interacting with their physical and sociocultural environments. It is the role of educators to provide conditions under which new experiences can be had by students so that they can discover and construct new knowledge for themselves [52]. Meanwhile, connectivists conceptualize learning as a networked phenomenon that relies on students participating in wider learning communities that allow for sharing, dialogue, and collaboration with peers or more knowledgeable others [53]. The internet can vastly expand these learning networks, and digital media, such as virtual reality, can take advantage of this by connecting to online learning resources from different educators, community groups, or organizations.

The degree to which such frameworks may be termed "critical" relies heavily on whether learning materials incorporate the goals of social and environmental justice [54,55]. In the case of Camosun Bog 360, Jerowsky seeks to engage students with socio-environmental issues in a reflective, age-appropriate way that highlights broader systems of oppression, while foregrounding the voices of marginalized communities, such as the Musqueam people or community-based organizations. Specifically, he integrated publicly available learning materials and video interviews that were developed by the Musqueam First Nation for local teachers seeking to emphasize Indigenous perspectives and critical-thinking practices in classrooms. Interviews with community volunteers by Jerowsky further expand on the overlapping experiences of those visiting Camosun Bog in the field trip, and sharing with students why they may choose to devote their time to protecting this space. In terms of promoting action competence, critical approaches to environmental education are key in such cases as they promote democratic participation through foregrounding the voices of those who are often underrepresented in the classroom.

When developing Camosun Bog 360, the goal was not to simply recreate an outdoor-nature experience for students. Indeed, some have been concerned that virtual field trips may detract from students actually exploring the outdoors, impacting their connection to nature, and subsequently, developing pro-environmental behaviors [56]. However, the transformative potential of virtual reality for environmental education does not rest in simulation, but in the reification of environmental processes and experiences that may remain invisible to learners based on timeframe, scale, or distance [41]. Camosun Bog 360 provides students with learning materials that help to plot environmental-restoration efforts over the past 20 years, allows them to compare the Bog in multiple seasons, provides the perspectives of multiple stakeholders who could not realistically be booked for a single outing, and allows students to virtually experience plants and animals which are not available during all times of the year. Further, those with reduced access to Camosun

Bog, due to economic factors, distance, or ability are provided a more immersive and engaging experience than they might have otherwise had. Additionally, the ability of community groups to provide informal learning opportunities is also improved through the use of Camosun Bog 360. Pacific Spirit Park Society, which regularly hosts outdoor nature walks for students in their community, has found that they have far more interest in their programs than their capacity allows for. The reliance on such organizations by public schools is not a new phenomenon, and directors within this society feel that Camosun Bog 360 may help them to better meet the needs of their community.

6. Discussion

6.1. Key Themes

Through this preliminary investigation, the authors sought to identify transferable learnings from informal environmental education initiatives that may be incorporated within formal curricula to enhance action competence in school-aged children and youth. Two approaches were explored, both of which had some common pedagogical tenets, despite being geographically and methodologically divergent. Some of the key themes arising from the two presented approaches are described herein.

Participatory/democratic approach to learning: First, both cases integrate participatory and democratic approaches for promotion of environmental and social justice and contribution towards attainment of the SDGs. Participation and engagement in the two cases also include provision of mentoring and networks of peers or knowledgeable others. The R&S Australia program combines both peer-to-peer and intergenerational knowledge exchange, while the CB360 program helps bring Indigenous and community-based perspectives into the learning environment, which may otherwise be difficult for students to access.

Experiential or immersive learning: Second, both cases seek to promote environmental knowledge through experiential or immersive learning. The R&S Australia program engages students in local projects that promote hands-on skill development through immersion in local projects. Students have the opportunity to witness the direct results of their efforts, e.g., through return of fauna species to a restored habitat. On the other hand, the CB360 program seeks to promote the reification of environmental processes through virtual immersion, and enabling more visceral learning experiences that may otherwise not be possible due to geographical, seasonal, or economic factors.

Self-directed learning: Third, in addition to immersion, the two cases incorporate self-directed learning. The R&S program allows students to select an environmental or social cause to which they feel a personal connection, and lead self-directed projects to identify and implement solutions. In this manner, they are able to apply an assets-based approach to their learning which focuses on leveraging their personal strengths and interests for creating a positive impact. Such approaches also foster personal and community leadership skills. On the other hand, the CB360 virtual field trip allows students to explore the Bog in any direction of their choosing. Furthermore, complementary learning materials which help students trace the history of environmental-restoration works at the Bog, and connections with local organizations (e.g., Pacific Spirit Park Society) afford additional pathways for self-directed follow-up volunteerism. Another key facet of this self-direction precept in both cases is reflexive thinking. The R&S program guides participants to evaluate and reflexively examine their own impact. The CB360 project invites students to consider their own positionality in regard to settler colonialism and how they fit into the broader ecological community of which they are a part.

Interconnectedness of SDGs: Lastly, on a broader ontological level, both cases implicitly address the interconnectedness of environmental and social issues, and the interplays between different SDGs. Since its inception in 1991, the R&S program has been rooted in an integrated approach for promoting the health and welfare of humans, animals, and the natural environment, a concept that is now commonly depicted by the term 'One Health' [57]. The CB360 program, too, is embedded within the broader socio-environmental context

of the Bog, and seeks to highlight the historic and current systems of oppression, and their interactions with environmental issues [58]. Both cases also seek to democratize the learning process: the R&S program achieves this through the dispensation of funds to learners around the globe, empowering them to make meaningful changes in their own communities; meanwhile, CB30 foregrounds the voices of marginalized communities who are underrepresented within formal environmental education curricula.

6.2. Recommendations for Practice

The case studies explored in this paper represent only two of countless informal learning programs for environmental and more broadly, SDG education available across the globe. However, much as Falk [28] suggests, we too think that educators should move to incorporate the lessons learned from such programming into formal educational environments to better foster action competence in sustainable development.

Specifically, the key themes or lessons identified in the two case studies we review included: (1) participatory and democratic approaches that engage the students themselves, stakeholders and knowledgeable others in the learning process, (2) immersive and experiential learning that promotes learning by doing (i.e., action-orientation), (3) self-directed and reflexive learning, and (4) recognition of the inter-connection between humans, animals, and the natural environment, and the interplays among the various SDGs. To translate these emergent themes into recommendations for formal curricula, we propose a **"Free-Choice Project-based Learning for Action Competence in Sustainable Development (AciSD) Curriculum"** that can be bolstered by educational technologies as appropriate and accessible. In this curriculum, students may be given the opportunity to partake in term-long or year-long team-project(s) within a hybrid classroom/real-world setting that allows them to:

- select an SDG and topic of inquiry of their choice (e.g., a specific local environmental or social justice issue), based on personal interest and curiosity;
- conduct self-directed exploration about solutions to the identified problem; and
- receive bespoke mentorship and domain-specific knowledge through formalized pedagogical support structures.

As previously discussed, we sought to translate the emergent themes into practical recommendations that are ready for adoption through the mechanism of existing pedagogical models. To this end, we have grounded our curriculum recommendations on a literature review of project-based learning conducted by Kokotsaki et al. [46]. Kokotsaki et al. identified six key recommendations for successful project-based learning within school settings. While Kokotsaki et al. recommendations on project-based learning may be utilised for any educational discipline (e.g., biology, mathematics, physics etc.), here we have specifically adapted their recommendations for creation of a project-based learning curriculum to support ACiSD. Kokotsaki et al.'s recommendations are commensurate with the key themes identified within the two case studies presented in this paper [46], for example:

1. Provision of student support is crucial so that students are effectively guided through the project process, including productive use of technologies, environmental literacy, and inculcation of soft skills, such as time management [59,60].
2. Teacher support should be provided through professional development opportunities, networking avenues, and buy-in from schools' senior management;
3. Effective group work should be fostered so that students may work with shared agency and participation;
4. Balancing didactic instruction with independent inquiry can help students gain the requisite technical knowledge (provided through recommended resources, educational technologies, or more traditional classroom-based curricula) so they are well equipped for independent work;
5. Reflection, self, and peer evaluation will enable students to think reflexively, monitor progress, and continually improve their work; and

6. Student choice and autonomy to provide students ownership and a sense of control over their learning and selection of project topics and target SDGs.

Our proposed Free-Choice Project-based Learning for AciSD Curriculum model integrates Kokotsaki et al.'s aforementioned recommendations with the emergent themes from our exploration, by delineating six key curriculum implementation dimensions, namely: (1) project duration and teaming arrangements, (2) topic selection, (3) student support, (4) teacher support, (5) learning environments, and (6) digital access and equity. This model is presented in Table 2. With the aid of a hypothetical worked example, we recommend action steps for educators to help them implement this curriculum in their specific educational settings. Where applicable, the relevant priority-action areas in UNESCO's ESD Roadmap are also highlighted in Table 2.

Table 2. Recommended Actions for Implementing Free-choice Project-based Learning for ACiSD Curriculum.

Implementation Dimensions	Actions and Considerations
Project Duration and Teaming Arrangements	• Determine the appropriate duration for implementation of the project-based learning curriculum, e.g., single or multiple school terms/semesters, entire school year etc. • Identify teaming arrangements for project-based learning. Projects may be completed by students individually or as part of small teams grouped together based on SDG of choice/topic of interest (See row below for more information). • **Worked example:** Ms. Rose is an educator who has implemented a free-choice project-based learning for ACiSD curriculum in her class. A group of three students ('The Green Thumbs') decide to work together on a year-long project.
Topic selection *ESD Roadmap Priority Action Area(s): Empowering and mobilizing youth (4); Accelerating local level actions (5)*	• Where possible, allow students to select an SDG of their choice. Alternatively, consider if a specific or pre-selected subset of SDGs should be focused on by the class. • Within the chosen SDG, guide students to define a specific scope or problem that they wish to address through their projects. • Determine what additional support students might need for self-reflection and decision-making on topic selection. • **Worked example:** The Green Thumbs are passionate about SDG 15: Life on Land, and SDG 13: Climate Action. They recently learnt in Science class that native tree species can help sequester carbon and provide habitat for the local birdlife, while also rejuvenating the soil. So, they decide to create a project to revegetate a barren parcel of land on the school property.
Student Support *ESD Roadmap Priority Action Area(s): Transforming learning environments (2); Empowering and mobilizing youth (4); Accelerating local level actions (5)*	• Guide students to reflect on what knowledge and skills they will need to complete their projects. • Consider if students need any additional structured support, knowledge, or skills to complete their projects and achieve their articulated goals. Examples may include additional educational resources for subject-matter knowledge, and soft skills such as time management, etc. • Identify which types of internal/external stakeholders might support students on their projects. Examples include designated teachers, community mentors/volunteers, peers, Indigenous educators, parents/family members, neighbors/local community members, senior students etc. • Develop a community of support for each project. • **Worked example:** The Green Thumbs, through a series of group discussions and guidance from their teacher, determine that they will need to: (1) identify which native species are best suited for their local environment; (2) understand more about the ongoing care these plants will need; (3) learn practical skills required for tree planting (e.g., how to safely dig soil, depth at which saplings should be planted, distance between saplings, whether certain species can be planted adjacent). One of the group member's neighbors is a member of a local Indigenous-led nature conservation collective and has a strong understanding of native flora species. The students also know that the school gardener is passionate about teaching children about gardening and tree planting. The Green Thumbs form a community of support with their designated teacher, school gardener, and Indigenous conservation mentor.

Table 2. *Cont.*

Implementation Dimensions	Actions and Considerations
Teacher Support *ESD Roadmap Priority* *Action Area(s): Building capacities of educators (3)*	• Identify what support mechanisms need to be put in place to support teachers to run project-based learning programs. Examples may include: professional development days, a peer learning/community of practice for teachers interested in project-based ACiSD education, online resources e.g., teachers' guides to help inform the implementation of a project-based learning curriculum. • Determine what additional resources might teachers need to integrate blended learning and technological resources in the classroom. • **Worked example:** As Ms. Rose is the first educator to implement this curriculum in her school, she joins a social-media peer community of teachers who are generally interested in self-directed and hands-on student learning and seeks their insights on supporting students in a self-directed learning environment. She also enlists support from her local library to loan a few environmental documentary DVDs to augment student learning.
Learning Environments *ESD Roadmap Priority* *Action Area(s): Transforming learning environments (2); Accelerating local level actions (5)*	• Identify the learning environments within which the students will learn (e.g., classroom, community spaces, parks, virtual spaces, libraries, museums, communal maker/connector spaces) • Determine the modes of learning which will apply to the student projects, e.g., online forums on SDGs, classroom discussions, multimedia resources, project Open Days at the end of the curriculum duration. • Identify the available/accessible technological resources that would enhance students' learning processes and outcomes. Examples may include multimedia available at local/school libraries, downloadable toolkits and resources, virtual museum exhibits. • Note: The above considerations may involve shared decision-making between students and educators. For example, students may propose their choices of learning environments and modes, with guidance from their educators, in particular regarding feasibility and logistics considerations. • **Worked example:** The Green Thumbs and Ms. Rose have a discussion and decide that the group will learn in a variety of environments, including the classroom, school library, and school gardens. Their Indigenous conservation mentor also recommends them to learn more about the local fauna species, as that would help them make decisions about which native vegetation species they should plant, to better support the broader eco-system. As such, the students use a mobile gaming application called Questagame which helps them survey their local natural environment and submit sightings of fauna species. • Ms. Rose also develops a closed online forum for the class. She engages two senior Biology students to act as online forum moderators and mentors. The online forum provides a platform for students to ask their peers and student mentors questions, share ideas, and help each other in a collegiate manner. • At the end of the school year, Ms. Rose holds an Open Day where all students get to present posters, dioramas etc., summarizing their accomplishments over the project duration. Parents, families, student mentors, community mentors, and school staff attend the Open Day and celebrate the real-world impact made by students.
Access and Equity *ESD Roadmap Priority* *Action Area(s): Empowering and mobilizing youth (4)*	• Where possible, consider any issues in relation to equity and access. For example, digital equity issues may stem from both access to technological devices, and ability to use the devices. • Educators may adopt different approaches for mitigating inequity issues. For example, in some cases some educators may elect to restrict the use of technology to communally available resources (e.g., through the school/local library/community center etc.) for all students to enable uniformity of access. For equity issues in relation to skill level, senior student or peer mentors may also aid learning. • **Worked example:** As part of the curriculum, Ms. Rose creates a reciprocal peer mentorship program in which students are required to dedicate one-hour per fortnight for mentoring a peer on a skill of their choice. Students are matched in pairs so they can work together and discuss ideas, and provide informal mentorship as applicable. One of The Green Thumbs' group members is adept at creating basic animations using an open-source DIY animation software and iMovie. She mentors a peer who is developing a short film about girls' education (SDG5: Gender Equality) as part of her ACiSD project. Ms. Rose also connects this student to a local library which can provide access to free internet and a computer, if needed outside of school hours.

It should be noted that the above curriculum model, in its current form, seeks to provide indicative guidance only. We acknowledge that there is often a paucity of time and resources in formal education settings. Thus, we encourage educators to adapt this guidance for their own settings, and apply relevant recommendations as logistically feasible. For example, it may not be logistically feasible to offer bespoke communities of support for each student or project team. Thus, educators may instead develop a single community of support with 1–2 volunteer mentors (e.g., one senior student, one community mentor) with whom all students may consult to seek additional guidance.

6.3. Limitations and Further Research

The current study is of an exploratory nature, with the selection of case studies driven by the authors' past work on the reported projects. The considerations identified are based on a non-systematic literature search, and thus, will need to be reinforced with a systematic review of literature and more thorough analyses of themes introduced in this paper. The authors also acknowledge gaps in education involving students with diverse learning and well-being needs [43,61]. While we have sought to include an equity dimension in the proposed curriculum model, other determinants of education, such as special learning needs, language, gender, socio-economic, and cultural background, need additional consideration, as these factors may impact students' levels of participation and learning outcomes [58,61–63]. Future research may include systematic evaluation of our proposed curriculum model. Future work to build on the preliminary ideas presented in this article may include, but will not be limited to, the development of supporting curriculum implementation tools, templates, and resources.

7. Concluding Remarks

This article analyzed two case studies of informal environmental education initiatives to identify learnings for promoting SDG action competence in school aged children. We present a preliminary Free-Choice Project-based Learning for Action Competence in Sustainable Development (ACiSD) Curriculum, comprising six implementation dimensions, namely: (1) project duration and teaming arrangements, (2) topic selection, (3) student support, (4) teacher support, (5) learning environments, and (6) digital access and equity. For each implementation dimension, we recommend action steps to help educators implement this curriculum in their own educational settings, with the aid of an illustrative worked example. We recommend formal education settings (e.g., schools) to incorporate self-directed project-based learning to augment environmental education programs and promote action competence for contribution to SDG attainment globally.

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