

An education approach for the Anthropocene epoch

Uma abordagem de educação para a época do Antropoceno

Un enfoque educativo para la época del Antropoceno

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Abstract

It is now well established in the literature that there is a need to incorporate the concept of sustainability into education at all study levels. However, there is considerable uncertainty expressed concerning how it could best be achieved and how the resilience concept would enhance this idea. This article aims to address this gap. The objective is to explore aspects of socio-ecological resilience, that underlies a university case study. The methodology is exploratory, descriptive, and explanatory. Results demonstrate that civil engagement university activities are an education approach that provides students with experiences that build skills necessary for addressing the challenges of the Anthropocene Epoch. The conclusion of the article emphasizes that the education for the Anthropocene epoch should consider the enhancement of ecosystem services by demonstrating that humans are part of the social-ecological systems; considering interdisciplinarity as a methodological approach; demonstrating the variety of potentials on participation of stakeholders by civil engagement as developing autonomy both on students and stakeholders and developing the ability for proactive attitudes. It also enhances learning and social learning by civil engagement and participation.

Keywords: Education; Anthropocene; Practical pedagogy analysis; Social-ecological systems; Resilience of ecosystem services.

Resumo

A necessidade de incorporar o conceito de sustentabilidade na educação em todos os níveis de ensino é consenso na literatura. Entretanto, existe uma considerável incerteza expressa sobre como melhor alcançar esse objetivo e se o conceito de resiliência poderá valorizá-lo. Este artigo aborda este tema. Seu objetivo é explorar os aspectos da resiliência dos sistemas socioecológicos, a partir de um estudo de caso universitário. A metodologia é de caráter exploratório, descritivo e explicativo. Resultados enfatizam que esse método de educação deveria proporcionar aos estudantes experiências que construam algumas das habilidades necessárias para enfocar certos desafios da época do Antropoceno. Entre as conclusões destaca-se que uma educação para a época do Antropoceno deveria considerar a valorização dos serviços ecossistêmicos. Dessa forma deve demonstrar que os humanos são parte dos sistemas socioecológicos e considerar a interdisciplinaridade como método de abordagem. Enfatiza-se ainda que essa educação deveria demonstrar a variedade de potenciais dos processos de participação de atores sociais por meio do engajamento social, como por exemplo o potencial de desenvolver a autonomia para estudantes e para atores sociais, e ainda explorar as habilidades para atitudes proativas. Conclui-se ainda que esses processos podem valorizar o aprendizado e construir o aprendizado social por meio do engajamento e da participação.

Palavras-chave: Educação; Antropoceno; Análise de prática pedagógica; Sistema socioecológico; Resiliência de serviços ecossistêmicos.

Resumen

La necesidad de incorporar el concepto de sostenibilidad en la educación en todos los niveles educativos es un consenso en la literatura. Sin embargo, existe una considerable incertidumbre expresada sobre la mejor manera de lograr este objetivo y si el concepto de resiliencia puede mejorarlo. Este artículo trata este tema. Su objetivo es explorar aspectos de la resiliencia de los sistemas socioecológicos, a partir de un estudio de caso universitario. La metodología es exploratoria, descriptiva y explicativa. Los resultados enfatizan que este método de educación debe proporcionar a los estudiantes experiencias que desarrollen algunas de las habilidades necesarias para abordar ciertos desafíos de la época del Antropoceno. Entre las conclusiones se destaca que una educación para la época del Antropoceno debe considerar la valorización de los servicios ecossistémicos. Por lo tanto, debe demostrar que los humanos son parte de los sistemas socioecológicos y considerar la interdisciplinariedad como un método de abordaje. También se enfatiza que esta educación debe demostrar la variedad de potencialidades de los procesos de participación de los actores sociales a través del compromiso social, como el potencial para desarrollar la autonomía de los estudiantes y actores sociales, y también explorar las habilidades para actitudes proactivas. También se concluye

que estos procesos pueden valorar el aprendizaje y construir el aprendizaje social a través del compromiso y la participación.

Palabras clave: Educación; Antropoceno; Análisis de la práctica pedagógica; Sistema socioecológico; Resiliencia de los servicios ecosistémicos.

1. Introduction

Global warming and many other human-driven changes to the environment are raising concerns not only in environmental and sustainability science, but in all domains of science and environmental education. Human activities have fundamentally altered the shape and the ecological functioning of the planet at local, regional and global scales. This profound impact of humans on the natural world has been marked by a new geological era in the history of the Earth, the Anthropocene era (Crutzen & Stoermer, 2000).

During the 2005-2014 decade, the United Nations (UN) addressed the need for education in sustainable development (UN, 2016). Sustainable Development education consequently promotes competencies in critical thinking, imagining potential future scenarios, and making decisions based on those potential futures in collaboration with stakeholders at every planning level. This requires far-reaching changes in the way education is practiced today. Human civilization faces local, regional, and global social-ecological challenges such as loss of biodiversity, rapidly changing ecosystem services, climate change, and poverty. These environmental and developmental challenges have fostered efforts to address the connection between biodiversity, ecosystems services and human health through the UN Millennium Development Goals that focus on decreasing poverty and improving quality of life by concentrating on education and policy that target of human well-being. (UN, 2016; UNDP, 2016).

Human wellbeing is inseparable from the natural world through the provisional, regulatory, and cultural services that ecosystems provide. Ecosystem services are the result of social-ecological interrelated process enhanced by the resilience of social-ecological systems (SES). Resilience is a perspective for the analysis of SES that emphasizes the need to understand and manage change, particularly unexpected change. Biggs, Schluter & Schoon, (2015) explains that “Like other approaches within the sustainability science field, resilience studies are fundamentally problem-driven and integrate a variety of disciplinary approaches and perspectives to help address the considerable sustainability challenges facing society” (p. 7).

The diversity of disciplines interconnected and early stage of the research and application of resilience work, however, led to a somehow dispersed and fragmented understanding of this subject to education in general. It is now well established in the literature that there is a need to incorporate the concept of sustainability into education at all study levels; however, there is considerable uncertainty expressed concerning how it could best be achieved (Jones, Trier & Richards, 2008; Wass et al, 2010) and how the resilience concept would enhance this idea.

This article aims to address this gap. The objective is to explore aspects of socio-ecological resilience education in the Anthropocene epoch that underlies the Novos Talentos outreach program at Regional University of Blumenau - FURB (BRAZIL). This course focus on enhancing student education for addressing 21st century social-ecological challenges and offer an opportunity to explore the mentioned gap from the perspective of its contribution to education. Our analysis is based on one critical question: What are the core education principals that provide students with the necessary skills to face the grand challenges of the Anthropocene epoch? From the methodological point of view, this article arises from a theoretical analysis based on bibliography research undertaken by the discussion on theory reviewed at the “Human development and the environmental, human life, and sustainability course” at WSU (Washington State University – USA).

Including this introduction and the final consideration this article expands on the “The Anthropocene epoch and the education challenges” (second section). At this section it is explained what means “Anthropocene epoch”. It also emphasized that the connective relationship that human interaction with the natural world can either erode or build resilience of a socio-

ecological system. At this point, it is argued what is the responsibility of educators in the “Anthropocene epoch”. The third section is about “Resilience in Anthropocene education”. The fourth section is about lessons taken from the experience of the author on “Human Development and the Novos Talentos” - FURB (Brazil). The title of the fifth section is “Toward an education approach for the Anthropocene epoch.

2. Methodology

The methodology of this article is exploratory, descriptive, and explanatory. It talks the Novos Talentos outreach programme as a case study to demonstrate that civil engagement university activities may be used as an education approach. Civil engagement universities activities, as reviewed at the article, may provide students with experiences that build the necessary skills for addressing the challenges of the Anthropocene Epoch. The qualitative perspective is used to answer questions and to build an approach with a broad universe of meanings, aspirations, beliefs, values, and attitudes. This sort of qualitative approach may correspond to a deeper space of relationships (Lüdke & André, 1986; Yin, 2015). The qualitative method is particularly appropriated for an applied study of an event or phenomenon. The qualitative methodology corresponds to the case of an individual phenomena or social process (Pereira, et al., 2018). The focus of a descriptive research may describe a situation, allowing the exact coverage of the characteristics of an individual or a situation, as well as unraveling the relationship between events (Selltiz et al., 1965). Explanatory research may seek to connect ideas to understand causes and impacts. The focus of this research is to understand the relationship between social-environmental system resilience and the education challenges of the Anthropocene Epoch, by describing the Novos Talentos outreach programme.

2.1 Human development and the Novos Talentos - FURB (Brazil)

In the past, universities have played a historic role in transforming societies and in serving the greater public good. The urgent societal need and broad call for sustainable development allow universities to assume a fundamental and moral responsibility in contributing to sustainable development and to guide society on its path towards a sustainable future. United Nations has made a call for the decade 2005-2014 to be a time for education for sustainable development. Sustainable development cannot be achieved by technological solutions, political regulation, or financial instruments alone. We need to change the way we think and act. This requires quality education and learning for sustainable development at all levels and in all social contexts (UN, 1998). This article argues for Eco-development, a pre-Brundtland concept that comprises local conditions, cultures, and capabilities. As a planning approach, education for eco-development needs to develop new strategies, practices on students, and address environmental concerns of the Anthropocene epoch.

Novos Talentos (funded by CAPES – Assessment Commission Agency for Higher Education - Brazil) plays that role. It is a university outreach program addressed to the undergraduate, graduate and elementary levels of education by civil engagement. It is particularly addressed to undergraduate landscape architecture and graduate urban/rural planning and elementary education students. The main objective is to improve environment awareness by the understanding of dynamic of water resources addressed for students and stakeholders of Blumenau. The methodology for the first two years was focused on working only with school’s teachers: 1st stage: Systems Dynamics and the pillar for eco-development; 2nd stage: eco-socioeconomic approach for education and; 3rd stage: Social-ecological design approach for enhance resilience of SES. Second and third year - 4th Stage: (funded by British council- CAPES) focused on Hands on activities based on the Social-ecological design of the 3th stage, leaded by stakeholders, elementary school, graduate and undergraduate students.

This outreach program is embedded on the assumption and environment of the Education for Eco-development Zone (EEZ), which is a space of pedagogical experimentation and practices consistent with the international perspective towards

trans-disciplinarity. Trans-disciplinarity is a steep of the interdisciplinary integration and of co-operation, which includes disciplines but also stakeholders as planners, administrators and local population (Santomé, 1998). The EEZ addresses concepts of ethics, epistemology and social-ecological systems attributes, taking into account local conditions, culture and capabilities. One of the priorities is the establishment of a network of scholars, undergraduate and researchers with the background in landscape architecture, geography, biology, geology, regional development and administration from the Regional University of Blumenau FURB (SC, Brazil) and teachers of six local schools and community members, besides the enhancement of the SES. At this program research design is developed by civil engagement activities proposed as an integrative social-ecological, educational, cultural and scientific process. The interaction between researchers and stakeholders enhances the learning process, enabling publications and dissertation, feeding back the process of designing and implementing new strategies.

“The Brazilian federal Constitution of 1988, Article 207, argues that universities should follow the principle of linkages of teaching and learning, researching and outreach”. Novos Talentos is developed in this concept in mind. Community development is, then, represented as a challenge for management of natural resources. Novos Talentos is a creative experiments focused at improving local community’s ability to interpret their own environmental concerns. During the Social-ecological Design approach step local demands were attended to put strategies into hands on experimentation (e.x. waste recycling or school activities to promote an interdisciplinary approach for elementary education; hill top housing/trees planting to enhance slope stability, etc).

Although FURB’s experience is not directly linked with class activities. Novos Talentos is addressed to schools of lower scores on their national assessment process, and therefore a university would have an important role on its education for sustainable development. FURB selected six schools of social vulnerable students, which out of five are situated in an area highly vulnerable to hazards, like floods and steep slopes housing. Novos Talentos takes place in Blumenau (Santa Catarina, Southern region of Brazil). It is an ecologically vulnerable region, and the city spans 518,497 km², predominantly urban at density of 595,97 inhab/km² (IBGE, 2010). Risk and social ecological indicators of lack of resilience are an ongoing part of Blumenau’s history. Its Ecological indicators of high environmental risk and intense rain, due to its temperate climate, increase the erosion of its social ecological systems. Social indicators include intense urban sprawl at river waterfront, erosion of steep slopes over harvest of wood resource. The combination between these variables has increased the social-ecological vulnerability to disasters.

Social ecological vulnerability to disaster and outcomes of any particular extreme event are influenced by building up eroding of socio-ecological system both before and after disaster occur. A better understanding of the linkages between ecosystems and human societies could help to reduce vulnerability and enhance resilience of these linked systems locally. Itajaí Valley (where Blumenau is situated) stands for one of the highest human development indicator (HDI=0,850) of Brazilian metropolitan areas, but its local community is highly vulnerable to disasters (Mattedi, 2009; UNDP, 2010). More and More adaptive response will be required for this valley to cope with frequent floods increasing as a result of global environmental change. One of the outcomes of the Hands on Solution Design was the learning process between university students, elementary schools students, school’s teachers and local community. This collaborative learning process is called social learning. A complement of learning that is believed to enhance the resilience of ecosystem services and benefits the environment and human wellbeing. Social learning refers to a change in understanding that goes beyond the individual to become situated within social units or communities of practice through social interactions between actors within social networks (Reed et al., 2006). It can be an outcome of social interactions (Olsson, Folke & Berkes, 2014).

Therefore, it can be directly related to a civil engagement activity. Numerous theoretical frameworks have been developed to understand how we learn. None of these frameworks are specifically about social learning, though they may be able to provide an understanding of the process upon which social learning is based (Reed et al., 2006, p. 3). It is believed that

people have concrete experience and may learn increasingly deeply as they reflect upon these experiences. But to what extent social learning leads to positive social-ecological outcomes? It is argued on literature that people learn from each other in ways that can benefit wider social-ecological systems. When an individual, group and/or organization choose to take an active role in decision making process, particularly civil engagement activities as it took place within Novos Talentos, they choose to take an active role in decision making processes that affect them. In this case students of the university, schools and stakeholders played a role on advancing the understanding on the resilience of social ecological systems of the risk areas where they live, they choose to take an active role on the process that directly affect them.

3. The Anthropocene Epoch and the Education Challenges

What is Anthropocene epoch, and why should education approaches address our planet's geologic time scales? The term Anthropocene from the Greek word "anthropo", human and "cene", new, was coined by the ecologist Eugene Stoermer and popularized by chemist and Nobel Laureate Paul Crutzen to emphasize the scale of human footprint on the chemistry, biology, ecology, and geology of Earth's life support systems (Crutzen & Stoermer, 2000). The Anthropocene is the current epoch in which human societies have become a global geophysical force. The Anthropocene began around 1800 with the onset of industrialization, the central feature of which was the enormous expansion in the use of fossil fuels (Steffen, Crutzen & McNeill, 2007).

The term Anthropocene suggests that the Earth has now left its previous natural geological epoch, the interglacial state called Holocene. Human activities have become so pervasive and profound that they rival the great forces of nature and are pushing the Earth into planetary terra incognita. The past century has seen the mass production and adoption of automobiles and electronics, large scale conversion of land to urban areas and agriculture, and an increase in the global population from 1.6 billion people in 1900, to over 7 billion in 2011 (MA, 2005, Steffen et al., 2007). The literature shows that Anthropocene epoch is thus far comprised of 3 stages: 1st stage - the industrial era (c.a. 1800-1945). The 2nd stage – the great acceleration (c.a. 1945-? 2015); and the 3rd stage –Stewards of the Earth System (a.c. 2015-?) (Mahaffy, 2014).

The 1st stage is characterized by the industrialization of the earth system made possible by the rapid expansion in the extraction and use of fossil fuels such as coal and oil (Steffen, Crutzen & McNeill, 2007). The imprint on the global environment of the industrial era was, in retrospect, clearly evident by the early to mid-20th century (Steffen et al., 2007). Human transformation of the hydrological cycle was advanced during this time through the introduction of a number of large dams, particularly in Europe and North America, and rapidly advancing technologies requiring more resource extractive practices. By 1950 the atmospheric CO₂ concentration had pushed above 300 parts per million (ppm), above its pre-industrial value of 270-275 ppm (Etheridge et al., 1996).

The second stage consisted of the acceleration of the human enterprise after the end of the second world war (Jones, Trier & Richards, 2008) and can be characterized by rapid changes in land use, desertification, loss of biodiversity, and changes to earth's water, nitrogen, and carbon cycles. Further, this phase saw population double in just 50 years, to over 6 billion by the end of the 20th century. From 1950 to 2000 the percentage of the world's population living in urban areas grew from 30 to 50%. The explosion in electronic communication and globalization of the economies made a significant difference at this stage. The atmospheric concentration of several green-house gases (CO₂, CH₄, N₂O and Fluorinated gases) have increased substantially, with the concentration of CO₂ reaching a seasonal high of 400 ppm in 2013. Greenhouse gases are linked to the rapid warming of the earth's biosphere which is decreasing ecosystems services and human health and well-being (IPCC, 2007).

The 3rd stage that the we are now entering, could be the turning point. Earth's life support system, ecosystem services and human induced pressures on this system is one of the greatest research and policy challenges ever to confront

humanity. This phase could be marked by rapid trends in dematerialization, shifts in societal values, and a focus on long term planning for resilient ecosystems, economies and societies. The question is, will it be strong enough to trigger a transition of society towards a much more sustainable one? (Steffen et al., 2007). Changing values is one of the most difficult tasks, because it also involves faith, religion, and deeply embedded cultural and institutional practices. Education can play an important role in the shift to a more sustainable behavior, if it is addressed by the argument that it relates to the subject if weather there will be a space for mankind on Earth. There could be no species preservation without habitat preservation, and no habitat preservation without local livelihood security (Gibons, 2006).

Sustainable development as proposed by the Brundtland Commission (WCED, 1987) became popular around polity initiatives, institutions and as an overall education approach. It is well argued that sustainability is an essential integrative concept. Education approaches tend to emphasize the study of social, economic and ecological system components separately, then struggle to integrate the separate findings. But it is in the connections and interactions between these components that the most important assumptions and information can be found. According to Ostrom (2009), in a complex social ecological system (SES), subsystems such as resource systems (e.g. a coastal fishery), resource units (lobsters), users (fishers), and governance systems (organization and rules that govern fishing on the coast), are relatively separable but interact to produce outcomes at the SES level, which in turn feedback to affect these subsystems and their components, as well other larger or smaller SESs (Ostrom, 2009, p. 419).

It is these connective relationships that human interaction with the natural world can either erode or build resilience of a socio-ecological system. Stakeholders with direct or indirect impacts on the overall structure and function of the SES play important role in designing projects, policy, and long-term planning strategies for sustainable development. All actors of society must contribute in the transition towards a sustainable world. This is the education challenge. Education can be a catalyst to work towards this goal. Education should highlight humans as an integral part of the social-ecological system, as we all live and operate in social systems that are linked to the environment in which systems are embedded; we exist within social-ecological systems (Walker & Salt, 2006, p. 31).

Investigating and responding to the rapid, largely Anthropocenic change has led to the recent appearance in our professional societies of new disciplinary and interdisciplinary scientific journals with Anthropocene in their titles. Research looking into how to incorporate education about the Anthropocene epoch into elementary, undergraduate and graduate levels (Mahaffy, 2014). It is the responsibility of educators to communicate the connection of humans and their environment, and to facilitate the building of skills to address the challenges of the Anthropocene, at all educational levels and across all disciplines (Mahaffy, 2014). What might be some of the ways educators could be using environmental issues data, along with an understanding of planet boundaries to help our students and the public to take informed actions as citizens?

4. Resilience in Anthropocene Education

Despite huge technological advances of this epoch, people still ultimately depend largely on nature for a variety of essential needs, including fresh air, clear water and food, protection from hazards such droughts and storm, and a wide variety of cultural, spiritual, and recreational needs that play a key role in human well-being (MA, 2005). Such benefits derive from the interaction of people with nature and are known as ecosystem services (Ernstson, 2013; Reyers et al., 2013).

Ecosystem services are directly related to the resilience of socio-ecological systems (SES). Over the past two decades the resilience approach has attracted increasing attention, and there has been as explosion of research into system attributes that may promote or undermine the resilience of ecological systems and ecosystem services upon which society depends (Walker, Salt, 2006; 2012; Berkes, Colding, & Folke, 2003; Biggs, Schluter & Schoon, 2015). A succinct definition of resilience is

about: “Resilience is the ability of a system to absorb disturbance and still retain its basic function and structure” (Walker & Salt, 2006, p. 1).

Resilience of SES is being addressed by a wide range of disciplines to attend the sustainability challenges. Resilience thinking tasks planners and decision makers to look closely at how systems function and change over time in response to external and internal perturbations, and determine whether those changes will bring positive or negative gains for ecosystem services that humans rely upon. Ideally, building human-ecological relationships that can absorb change without compromising the overall function of the socio-ecological system. The Stockholm Resilience Centre, by Biggs, Schluter and Schoon (2015), poses 7 principles for building resilience, which we believe are critical for education in the Anthropocene epoch:

“Maintain Diversity and Redundancy”: Social, economic, ecological and institutional diversity and redundancy enhances a socio-ecological systems ability to respond to the grand challenges of the Anthropocene epoch (p.50); (ii) **“Maintain Connectivity”**: Ecosystem connectivity can greatly improve biodiversity of systems; however, systems that are overly connected and rigid will not respond to the grand challenges. It is important to identify and enhance important social-ecological interactions/connections (p. 80); (iii) **“Manage Slow Variables and Feedbacks”**: Slow variables (geographic and/or time scale) control how socio-ecological systems function and the ecosystem services provided. Managing these slow variables through monitoring and adaptation is key for addressing the grand challenges (p.105); (iv) **“Foster complex adaptive systems thinking”**: Systems thinking, adaptive response and acknowledgment of uncertainty are critical for building resilience (p. 142) ;(v) **“Encourage learning”**: Systems change, therefore planners and decision makers need to be able to adapt as new information is gained and knowledge is shared (p. 174); (vi) **“Broaden participation”**: Learning, trust and the building of shared understandings of the socio-ecological system can be built through wide spread stakeholder participation. Community engagement is an integral part of education in the Anthropocene epoch (p.201); (vii) **“Polycentric governance”**: This type of governance focusses on the connection of “nested institutions” to enhance collaboration on complex socio-ecological issues (Biggs, Schluter & Schoon, 2015, p. 226).

What is learning? According to Säljö, (1979), “Learning is a multifaceted phenomenon and includes: i) acquiring information; ii) memorizing; iii) acquiring facts skills or methods; iv) making sense or abstract meaning; v) interpreting and understanding reality in a different way by reinterpreting knowledge” (p.7).

There are some collaborative learning processes that can include/or called social learning that may enhance the resilience of ecosystem, and the principals mentioned above as principal v) “Encourage learning” and (vi) “Broaden participation”. Social learning is a complement of learning that is believed to enhance the resilience of ecosystem services and benefits the environment and human wellbeing. Social learning refers to a change in understanding that goes beyond the individual to become situated within social units or communities of practice through social interactions between actors within social networks (Reed et al., 2006; Tippett et al., 2005). Social learning is exemplified by the Novos Talentos outreach program, the case study that is described at this article.

In order to understand the relationship between the second principle (ii) “Maintain Connectivity and biodiversity there should be seems that there is a relationship between **biodiversity and resilience** of ecosystem services. On the resilience concept the presence of multiple elements with similar functioned roles (e.g., different species of edible fish) provides redundancy and allow for the possibility of substitution among elements, these providing back up or insurance through process known as functional compensation. Redundancy is even more valuable if the element providing the redundancy also differ from each other in their response to disturbance (response diversity) (Biggs, Schluter & Schoon, 2015, p. 55). Thought they will continue delivery particular ecosystem services in the absence of other elements. For example: If they would have been overharvested.

But within what ways can the principles of resilience can enhance education for the Anthropocene epoch? There are ways in which social-ecological issues are brought to education to meet the challenges of the Anthropocene epoch. For this task experience and knowledge should be put together to enhance the leaning process and therefore improve biodiversity. A

component of civil engagement could enhance teaching methodology and principle (v) encourage learning and (vi), broaden participation, and so on. But what is civil engagement? To be civically engaged means to actively participate in community/society to improve quality of life. It also involves the process of developing the skill, knowledge, and motivation to make that difference. The CCE offers FURB students, faculty, campus departments and community partners' opportunities to share knowledge, skills and resources for the benefit of student learning and the wellbeing of the communities nearby.

Knowledge is gained from the CE activity, informed by knowledge gained in the classroom. The CE activity brings the learning full circle through reflection. Reflection looks at the CE project accomplishments, ask students to think about how the project fits into the bigger picture at local, regional, and global scales, and ask them to apply the knowledge gained to other projects/problems they will encounter in the future. After the learning occurred students are then able to derive abstract concepts from these experiences and apply what they have learned through active experimentation in other places of the town. That idea can be demonstrated at Novo Talentos Outreach program at FURB (BRAZIL).

5. Toward an Education Approach for the Anthropocene Epoch

The Domain for education for Anthropocene epoch lies in the assumption of rethinking about new what has lead us to the planet terra incognita. Global change should be proactively addressed. Education is a strong power that could enhance change of values, but we have to be in mind that the call is urgent. "In most parts of the world the demand for fossil fuel overwhelms the desire to significantly reduce greenhouse gas emissions (Steffen et al., 2007). About 60% of ecosystem services are already decreased and will continue to degrade further unless significant societal changes in values and management occur (MA, 2005).

An education approach for the Anthropocene epoch following the highlighted subjects of this paper around the experience of FURB to enhance the resilience of the planet and minimize loss of ecosystem services, would need to be a global call for education for eco-development. In that sense, it would address local conditions, culture and capabilities to be able to understand social-ecological system dynamics of each particular country across scales. Therefore there is a need to develop perception of system thinking and system dynamics by the awareness that scales are linked.

The linkages across scales play a major role in determine how the system at another (linked) scale is behaving. Sometime the linkages and interactions seem obvious, but frequently they're only acknowledging in retrospect (Walker & Salt, 2012, p. 17). With that concept in mind, interdisciplinary comes explicitly, as we are looking into social-ecological system. There is also a need for hybrid methodologies, as social-ecological issues are not only on the domain of environmental science but also on the social science and sustainability science. Although interdisciplinarity is not enough for this emergent call, the demand call for transdisciplinarity, as well, as we investigate the relationship between the subject and the object. The object (local conditions) is better interpreted by developing stakeholder participation. First, participation on a variety of stakeholders including those with non-scientific experimental knowledge, it can promote understanding of the SES dynamics by providing a range of social ecological and political perspectives (Walker & Salt, 2012; Biggs, Schluter & Schoon, 2015) that may not be acquired though more traditional scientific process.

As we have learned from FURB's case studies participation of stakeholders /local community can help to develop innovative solutions, as on the hands on social ecological design, for Blumenau's resilience of sliding sloop step hilltop housing concerns, waste management and so on. The relationship between stakeholders and researcher has potential to build trust and understand as a basis for collective action, around approaching situation of floods or any threshold. Within this case study the methodology approach advanced demonstrates that learning and social learning can be a positive outcome of civil engagement university activities that leads to a positive social-ecological process. It can enhance biodiversity and therefore

builds up ecosystem services. Another core principal for education for the Anthropocene epoch is to develop autonomy on students and stakeholders.

The university should lead the eco-development process for some time, but it should let stakeholders to be proactive in any particular situation. Stakeholders are able to derive abstract concepts from these experiences led by the university and apply what they have learned through active experimentation in other situation when social-ecological systems are approaching thresholds. Therefore autonomy should be developed in a time for proactive attitudes. The meaning of autonomy as from the dictionary “Oxford” (2004) is the individual possession or right of self-government. It comes from autonomous 'having its own laws', from *autos* 'self' + *nomos* 'law' (Oxford, 2004). Throughout the highlighted learning process one can acquire skills that allow him to be more autonomous.

6. Final Considerations

In summary, researchers and policy decision have already defined the need for Education for sustainable development but have not highlighted the need to clarify the methodology to be more integrative as concern social, environmental, and economic issues and not simply struggled with how to integrate the separate findings. Even more, we emphasize the need to distinguish sustainable development from eco-development, an approach that considers local conditions, culture and capabilities as a way to understand the role of stakeholder's participation and biodiversity. Building on this discussion, we propose that if education for the Anthropocene epoch is to consider the enhancement of ecosystem services, it must:

- a) Demonstrate that humans are part of the social-ecological systems, stressing that we all live and operate in social systems inextricably linked with the ecological system in which systems are embedded.
- b) Consider interdisciplinarity as a methodological approach, but go beyond interdisciplinarity, there must become situated within transdisciplinarity by investigating the relationship between the subject and the object throughout stakeholders' participation. So, it should consider stakeholders as a variety of actors including those with non-scientific knowledge.
- c) Demonstrate a variety of potentials on participation of stakeholders by civil engagement: i) building of trust and innovative solutions; ii) developing autonomy both on students and stakeholders; iii) developing the ability for proactive attitudes and collective action; iv) facilitates local conditions interpretation and monitoring.
- d) Enhance learning and social learning by civil engagement and stakeholder's participation.

As such, education for the Anthropocene epoch may be defined as a change in understanding that goes beyond interdisciplinarity to become situated within a wider social-ecological context system or communities of practice through social learning interactions across scales, acknowledging the enhancement of resilience of SES. It is expected that this response helps to clarify the conceptual basis for education for the sustainable development and eco-development helping to incorporate sustainability on education at all study levels, and how resilience concept would enhance this idea. If future research builds on the understanding that emerges from this discussion, we will be able to facilitate education more effectively for the Anthropocene epoch processes that may potentially enhance the sustainability of social-ecological systems. Future research also needs to assess more deeply the extent to which participatory process leads to positive social ecological outcomes. The objective of developing the perspective of education for the “Anthropocene epoch” has important elements for an education approach of populations living at the Blumenau's risk site, that is, Blumenau's socio-environmental vulnerability site, which were described by Souza et al. (2021).

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References

- Berkes, F., Colding, J. & Folke, C. (2003). *Navigating social ecological systems: building resilience for complexity and change*. Cambridge University Press:
- Biggs, R., Schlüter, M. & Schoon, M. L. (2015). *Principles for building resilience: Sustaining Ecosystem Services in Social – Ecological Systems*. Cambridge University Press.
- Crutzen, P. & Stoermer, E. F. (2000). The Anthropocene. *Global Change Newsletter of International Geosphere-Biosphere Programme*, 41, 17-18. <http://www.igbp.net/download/18.316f18321323470177580001401/1376383088452/NL41.pdf>
- Ernstson, H. (2013). The social production of ecosystem services: a framework for studying environmental justice and ecological complexity in urbanized landscapes. *Landscape and urban planning*, 109, 7-17. <https://doi.org/10.1016/j.landurbplan.2012.10.005>
- Etheridge, D. M. *et al.* (1996). Natural and Anthropogenic changes in the atmosphere Co2 over the last 1000 years from air in Antarctic ice. *Journal of Geophysics*, 101, 4115-4128. <https://doi.org/10.1029/95JD03410>
- Gibson, R. B. (2006). Beyond the pillars: sustainability assessment as a framework for effective integration of social, economic and ecological considerations in significant decision making. *Journal of environmental assessment policy and management*, 8(3), 259-280. https://edisciplinas.usp.br/pluginfile.php/223053/mod_resource/content/1/526_sa_gibson.pdf
- IBGE - Instituto Brasileiro de Geografia e Estatística. (2010). *Brasil cidades, 2010*. <http://www.cidades.ibge.gov.br/xtras/home.php>
- UNDP – United Nation Development Programme (2016). Human Development Index, HDI. <http://hdr.undp.org/en/content/human-development-index-hdi>
- IPCC - International Panel for Climate Change. (2007). *Synthesis Report*. https://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm
- Jones, P., Trier, C. J. & Richards, J. P. (2008). Embedding Education for Sustainable Development in higher education: A case study examining common challenges and opportunities for undergraduate programmers. *International Journal of Educational Research*, 47(6), 341-350. <http://dx.doi.org/10.1016/j.ijer.2008.11.001>
- Mattedi, M. A. (2009). O desastre se tornou rotina. In: Frank, B. & Sevegnani, L. (Eds.). *Desastre de 2008 no Vale do Itajaí: água, gente e política*. Blumenau: Agência da Água do Vale do Itajaí, 2009.
- Mahaffy, P. G. (2014) Telling time: chemistry education in the anthropocene epoch. *Journal of Chemical Education*, 91, 463-465. [10.1021/ed5001922](https://doi.org/10.1021/ed5001922), 0.76.
- MA - Millennium Ecosystem Assessment (2005). *Ecosystem and human well-being: synthesis*. Island Press, Washington. <https://www.millenniumassessment.org/documents/document.356.aspx.pdf>
- Olsson, P., Folke, C. & Berkes, F. (2014). Adaptive co-management for building resilience in socioecological systems. *Environmental Management*. 34(1), 75-90. [10.1007/s00267-003-0101-7](https://doi.org/10.1007/s00267-003-0101-7)
- Ostrom, E. (2009). A general framework for analyzing sustainability of social ecological systems. *Science*, 325(5939) 419-422. [10.1126/science.1172133](https://doi.org/10.1126/science.1172133)
- Oxford (2014). *Oxford advanced learner's dictionary*. Oxford University Press, 2004.
- Reed, M. S. *et al.* (2006). What is social learning? *Ecology and Society*, 15(4), 1. <http://www.ecologyandsociety.org/vol15/iss4/resp1/>
- Reyers, B. *et al.* (2013). Getting the measure of ecosystem services: a social-ecological approach. *Frontiers in Ecology and the environment*, 11, 268-273. <http://www.jstor.org/stable/23470507>
- Säljö, R. (1979). *Learning in the learner's perspective: some common-sense conception*. Reports from the institute of Education, University of Gothenburg.
- Santomé, J. T. (1998). *Globalização e interdisciplinaridade: o currículo integrado*. Artmed.

Souza, C. M. M.; Mello, B. J.; Florit, L. F.; Ramalho, A. M. C.; Souza, Y. M. M.; Jeremias, J. T. F. & Aguiar, P. D. (2021). Social environmental vulnerability approach on the COVID-19 epoch: a case study in Blumenau (SC), Brazil. *Research, Society and Development*, 10(10), 1-17 - 17. <http://dx.doi.org/10.33448/rsd-v10i10.1873>

Steffen, P. J. W., Crutzen, P. J. & McNeill, J. R. (2007). The Anthropocene: are humans now overwhelming the great forces of nature? *Ambio - Royal Swedish Academy of Science*, 36 (8). [http://dx.doi.org/10.1579/0044-744792007\)36\[614:TAAHNO\]2.0.CO;2](http://dx.doi.org/10.1579/0044-744792007)36[614:TAAHNO]2.0.CO;2)

Tippett, J. et al. (2005). Social learning in public participation in river basin management – early findings from Harmoni COP European case studies. *Environmental Science & Policy*, 8(3), 287-299. <https://doi.org/10.1016/j.envsci.2005.03.003>

UN - United Nations (2016). *United Nation millenium development goals*. <http://www.un.org/millenniumgoals/>

UN - United Nations (1998). *Education for sustainable development*. <http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-sustainable-development/>

Walker, B. & Salt, D. (2006). *Resilience thinking: sustaining ecosystems and people in a changing world*. Island press.

Walker, B. & Salt, D. (2012). *Resilience practice: building capacity to absorb disturbance and maintain Function*. Island press.

Waas, T., Verbruggen, A. & Wright, T (2010). University research for sustainable development: definition and characteristics explored. *Journal of clear production*, 18(2010), 629-636. [10.1016/j.jclepro.2009.09.017](https://doi.org/10.1016/j.jclepro.2009.09.017)

WCED - World Commission on Environment and Development (1987). *GH Brundtland chair: Our Common Future*. Oxford, New York: Oxford University Press. <http://www.un-documents.net/our-common-future.pdf>