

From creative writing, virtual environments to nature-based solutions: linking research and education to facilitate transition from sustainable to regenerative cities

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ABSTRACT: Challenges related to the climate crisis and its consequences, such as rising sea levels, urban heat islands or floods, engender pressure on architectural education. Sustainable design often inclines to regenerative one - an emerging trend focused on the restorative power of architecture. The question appears upon the tools and methods that would facilitate both students and academics to address new challenges. This article offers insights into one of such methods based on the integration of students into research programmes. The European Union's Horizon 2020 research project SOS Climate Waterfront and follow-up interdisciplinary courses and events offered to students at Gdańsk University of Technology, Poland; KTH Royal Institute of Technology, Stockholm, Sweden; and Laval University, Quebec City, Quebec, Canada, are presented to illustrate this process. Starting with research by design approaches, and continuing with follow-up initiatives, groups of students gradually extend their areas of experimentation empowering urban designs with nature-based solutions (NBS), building their critical reflection through an immersion in the science-art-engineering nexus, virtual experience of nature or through creative writing about climate futures. Published, exhibited and awarded students' works confirm numerous benefits and efficacy of the proposed research-based architectural education.

Keywords: Climate change, futures, regenerative design, architectural education, nature-based solutions, waterfronts

INTRODUCTION

Challenges related to the climate crisis and its consequences, such as rising sea levels, urban heat islands or unprecedented flooding events, engender pressure on architectural education. With the publication of strategic documents revealing the scale of the crisis and envisioning new strategies, such as the New European Bauhaus or the Green Deal, a new field of reflection opened up for the schools of architecture [1][2]. In 2020, the European Association for Architectural Education (EAAE), an international organisation integrating schools of architecture in Europe issued a guiding document, the Oslo Pledge for Climate Crisis and Sustainable Future with an articulated message: *Change the game - take responsibility - nurture sustainability - change the world* [3]. This document is one of the pioneering that acknowledged the urgency of integrating both research and education into the pursuit of resilient and sustainable cities.

We promise to incorporate the current concerns into common values and to choose the right measures in aligning our curricula and research to confront these wicked problems with the urgency, leadership and prominence they demand, hereby aiming for the construction of a shared European frame of reference [3].

The announcement of the Oslo Pledge has started the discussion on how architectural curricula could be transformed. In 2024, four years later, this question appears even more complex, as it becomes increasingly evident that design requires surpassing the goal of sustaining the environment in its current state for future generations. It becomes crucial to move beyond mere sustenance and embark on a more ambitious and restorative path toward creating healthy environments and liveable cities with symbiotic relationships with nature. Many territories and places demand ecological transformations. Regenerative design could be depicted as a trend that has arisen as a response to the degradation of ecosystems. It aims to foster their restoration and is founded on the concept that architecture and urban design have the potential to revive harmonious coexistence between humans and nature.

These new aspirations entail going beyond the discipline of architecture and urbanism in design and planning, require the integration of different fields of knowledge and demand interdisciplinary discussions. Firstly, it becomes clear that challenges related to the climate crisis, such as threats of flooding, jeopardised biodiversity but also the need for green energy transformation, cannot be resolved within one discipline. Waterfronts are very particular areas: they are important public spaces but also sensitive laboratories [4-6]. They are vulnerable, holding delicate ecosystems and simultaneously dealing with urban pressure [7]. For example, as natural marshes vanish due to coastal erosion induced by climate change and human actions, newly established marshlands, integrated into waterfront transition projects,

may aid in the restoration of shoreline ecological functions [8]. Additionally, the pace of changes related to technology development, particularly the growing availability of AI tools, imposes cross-boundary educational challenges that cannot be easily addressed by a generative cumulation of the existing approaches. As it is well acknowledged, fostering creativity comes through transdisciplinary approaches [9-11]. Consequently, new complementary questions have been posed in 2024 by the EAAE Council:

How important is it to invite other disciplines in education, other forms of knowledge, in relation to the challenges of the climate crisis? What do our times demand and how can we help the new generation of designers to work in a regenerative way? [12].

The most important dilemmas, however, concern the possible educational procedures, tools and methods that would facilitate students' understanding of the complexity of the climate-related challenges and creatively address them. Formal curricular requirements, which in the case of European universities are defined by the Professional Qualifications Directive 2005/36/EC of the European Parliament and national standards regulations on the education of architects, are not always changing at a satisfactory pace. A lot depends on the individual approaches of academic teachers who face the scarcity of procedural guidance. This article is part of this discussion and it aims at presenting the efficacy and educational benefits of integrating students into research programmes. The European Union's Horizon 2020 research project SOS Climate Waterfront and follow-up interdisciplinary courses and events offered to students at KTH Royal Institute of Technology, Stockholm, Sweden; Laval University, Quebec City, Quebec, Canada; and Gdańsk University of Technology (Gdańsk Tech), Poland, are presented to illustrate this process.

The project SOS Climate Waterfront was focused on providing insights into possible scenarios for the future development of vulnerable waterfront spaces, but also on gathering data concerning soil erosion along coastlines, creating new synergies between disciplines and triggering innovative approaches based on the intersection of art, architecture, urban planning and engineering. Integration of different disciplines, such as economy, history, ocean engineering, architecture, urbanism, landscape architecture, data management and environmental engineering provided the programme with a sound base for identification of innovative and transdisciplinary approaches. Follow-up courses let students creatively deal with different geographical and environmental conditions while developing ideas and concepts for the City of Islands in Stockholm, Sweden, the Saint Lawrence River bank in Quebec, Canada, and the lowland waterfront territories in Gdańsk, Poland.

METHODS

As part of the SOS Climate Waterfront activities involved students were encouraged to participate in conferences, seminars, webinars and art exhibitions related to the project. This included the study of reports, such as the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Environment Programme (UNEP), as well as academic articles authored by experts in their fields [13]. Introductory seminars with researchers, artists, representatives of municipal planning agencies and stakeholders gave important interdisciplinary insights into the topic. Special attention was given to the intersection of art, architecture and engineering. These sources contributed to the general understanding of the subject matter and were employed to develop briefs for projects for particular locations and subsequently the research-by-design proposals during the SOS Climate Waterfront research workshops. The proposed concepts were discussed against implementation planning instruments during concluding seminars and disseminated during exhibitions. This transdisciplinary approach offered unique insights into waterfront transformations and has been continued in numerous follow-up educational initiatives. Researchers involved in the research project proposed followed-up seminars, workshops and design studios, and encouraged students to undertake a research-by-design Master thesis focused on regenerative design for climate-sensitive urban waterfronts, as shown in Figure 1.

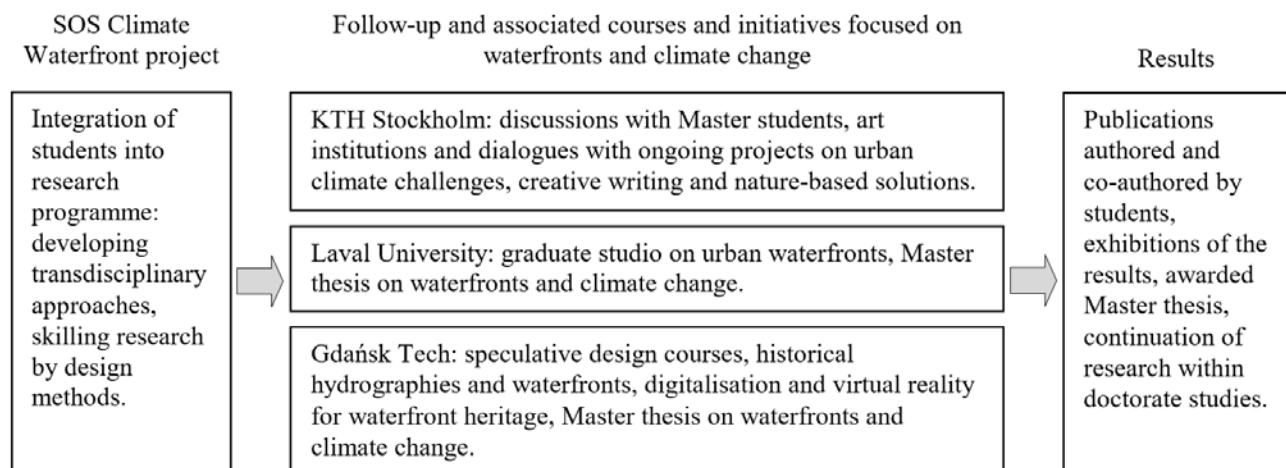


Figure 1: Stages of working with students and results of this work.

Within the framework of these follow-up initiatives, students were acquainted with scenario-building methods [14][15], experienced virtual forms of the land-water interface represented in digital art, delved into the role of media art virtual

environments in understanding and experiencing cities [16-18], participated in classes on co-creation and creative writing about climate future [19]. This diversity of methods and varied geographical and morphological conditions became excellent material for creative cross-discussions as a basis for further research and joint studio development.

The evaluation of the results is qualitative. Published, exhibited and awarded student works confirm the benefits and effectiveness of the proposed research-based architectural education. Master's theses conducted through research-by-design methods, along with publications stemming from these theses, validate the high level of preparation of graduates to address the challenges of climate change and to pursue further academic paths in this field within doctoral studies.

RESULTS

The integration of research and educational activities brought about compelling results in the two stages of the study that is during the workshops organised within the framework of the SOS Climate Waterfront project and during the follow-up educational initiatives. Students participating in the project delved into transdisciplinary perspectives on climate change consequences for cities. They demonstrated creative thinking while negotiating their approaches and elaborating design proposals for urban waterfronts. The transdisciplinary thinking linking urban planning with landscape architecture, green energy production, rainwater harvesting and nature-based solutions (NBS) brought innovative factors into negotiating a new land-water interface. The follow-up educational initiatives provided by schools of architecture varied - all of them offered particular insights into the future of waterfronts and encouraged students to develop their creative approaches.

A Historical City on Islands with Dialogues about Pedagogy for Climate Challenges, KTH Stockholm, Sweden

The dialogues between different disciplines are a challenge that can foster awareness of different approaches and practices to address climate challenges in the urban context. The combination of fieldwork in smaller teams provided opportunities for in-depth discussion on pedagogical approaches and cross-disciplinary assumptions used in different national settings and disciplines [20], also affecting ways in which students, including engineering students, take on challenges of future consequences of climate change. From the experiences in the Stockholm context, it also became clear that development of local policy for preventing severe consequences of climate change, involves several different actors. Walking with representatives from the Ports of Stockholm authority and meeting local municipality representatives gave access to an understanding of challenges and opportunities for an urban hub, such as Stockholm.

The long time horizons affecting the city of many islands are important to keep in mind. The ongoing process of land-rise caused by previous ice age periods and contemporary changes causing a warmer climate in Sweden [21] sets the stage for the need for an insightful discussion about new green areas required, also in new developments, to cope with challenges in the urban context, including heat islands and flooding. In the fieldwork activities carried out in Stockholm within the SOS Climate Waterfront project, the case study of Lövholmen, an industrial site now undergoing transformation prompted a discussion on historical evolution of the urban site and use of innovative materials for safeguarding future expected consequences (flooding, etc) from climate change.

The dialogues within the SOS Climate Waterfront project in the Stockholm context also paved the way for discussion at the European level about how European cities can prepare for climate challenges ahead. Furthermore, the relation between science, art and engineering was explored in a workshop with questions about in what ways can co-creative processes between art, science and engineering contribute to novel solutions [22]. The dialogues on urban climate challenges and exchange of experiences from historical solutions in waterfront cities across Europe, from Rome to Thessaloniki, Stockholm and Gdańsk, was a quest to craft strategies for future actions. This work was also inspired by ongoing research at KTH Royal Institute of Technology in collaboration with the art institution Färgfabriken (the Paint Factory) in Stockholm. In this co-creative process, researchers were exploring how citizens and local policymakers perceive willingness to adjust to consequences of climate change (such as increased risk of flooding) and urban strategies to use public spaces, such as parks in the urban context as a buffer zone.

Another example of approaches that may explore different narratives on future options can be found in popular science writing. Providing students with tools to communicate climate futures helps them visualise potential urban spaces. KTH researchers have initiated these dialogues on popular science writing and creative writing workshops together with engineering students, using visual digital boards to post, share and discuss the character of different climate futures. These narratives range from the anticipation of some technological solutions that will solve immediate concerns related to climate change to the evolution of habits and community responses being more specialised to cope with new urban challenges. These narratives can work as an inspiration, but also as an alarm clock when looking ahead towards new actions and strategies for urban climate adaptation that go beyond new technology.

The Saint Lawrence River Bank in Quebec: Graduate Studio on Urban Waterfronts, Laval University, Canada

The presented elective course aimed to develop the understanding, synthesis, evaluation and expression of the ideas underlying the development of advanced architectural design, adding an analytical and critical dimension specific to graduate studies. The problematic and exploration tools were driven by the theme of urban waterfronts in times of climate change. The course required research and creative thinking relevant to an interdisciplinary approach to design. Disciplines integrated into the design included social, artistic, environmental, anthropological and technological aspects.

The debate enhanced specific skills at the cultural level, including visual arts, geography, urban and landscaping, construction and structural techniques that influence architecture and the built environment. Additionally, the knowledge of historical solutions was studied to inspire designing low-tech and low-maintenance future strategies.

Participating students had the opportunity to integrate knowledge based on scientific reports about the local community and the natural environment. They were encouraged to use interdisciplinary knowledge of low-carbon energy strategies and adaptation to the local environment. Managing new information and its systematisation led to proposing innovative solutions from a technical, social, energetic or artistic point of view. Finally, interdisciplinary reflection was encouraged in the search for climate-sensitive solutions. The course intended to develop the ability to formulate complex solutions within a contemporary theoretical framework, to critically support the coherence of architectural design. The interdisciplinary framework promoted the exploration of new scientific and cultural perspectives.

Through this method, students proposed innovative solutions and advanced the techniques of critical thinking. According to the conducted survey, the studio was appreciated by graduate students as it guided them in developing creative capacity and prepared with specific instruments, both cultural and technological. It was finalised with a creative cross-cultural discussion, and works were exhibited. One student decided to elaborate further his research findings and present them in the form of a research publication [23]. The development of analytical and critical thinking of vulnerable waterfronts has given skills and tools to graduate students that offer outstanding capacities to deal with complex design problems. Most participants have used the outcomes of their design studio as the flagship in their portfolio to show their capacity to design creatively. The attractiveness of each proposal comes from the singularity and the interdisciplinary character of design to solve contemporary and emerging challenges.

Negotiating the Land-water Boundaries on Lowlands, Gdańsk Tech, Poland

To delve deeper into the topics explored by students participating in the research programme, several associated and follow-up courses were offered by the academics participating in the SOS Climate Waterfront project. Students attending one of such courses gained knowledge on developing design scenarios for different levels of water, linking artistic visions with environmental data and technologies for flood-resilient architecture and public spaces [14]. Another interesting insight emerged from the participation of students in the Waterfront and Heritage design studio. The rationale for proposing such a topic stemmed from the increasingly visible discourse on the importance of integrating cultural heritage into climate action. Despite the urgent need to include heritage perspectives in climate adaptation plans, there are still many unabridged gaps - theoretical, procedural and conceptual [24].

The course brought about compelling results. Firstly, students proved, using the research-by-design method, that the historical hydrographies that unveil how former generations living on the vulnerable territories dealt with water management could be successfully guiding today's concepts for waterfront transformations. Secondly, they had an opportunity to reconsider today's transformation process as an ongoing continuous operation. Students placed on maps the remains of former structures that are now submerged underwater, which deepened their understanding of the dynamics of landscape changes.

The integrated architectural and environmental engineering design studio offered as a joint initiative of academics representing the Faculty of Architecture and the Faculty of Civil and Environmental Engineering let students link their competencies and develop transdisciplinary concepts for rainwater management. While providing the demanded rainwater capacity the proposed reservoirs were designed to enhance the quality of urban life and increase the amount of de-sealed soil to provide greenery and reduce the impact of flash floods. The advantages of linking disciplines and approaches were an incentive for proposing another elective seminar and design course focused on linking walkability and place-making strategies with environmental perspectives, with the post-shipyard areas in Gdańsk as a case study.

Participating students enhanced their skills to combine conceptual thinking with spatial modelling and the use of software tools for environmental analyses. Subsequently, they layered human-centred approaches with the environmental perspective focused on the restoration of ecosystems, increasing the amount of greenery and at the same time preventing pluvial flooding. Eleven students participating in the associated and follow-up SOS Climate Waterfront courses (2020-2024) delved further into the topic of waterfronts and climate change developing their Master thesis. They investigated the new roles of in-between territories on the land-water interface from various perspectives - architectural, ecological, social spatial and geographical. They dealt with diversified typologies of waterfront territories - from post-industrial urban waterfronts to low-laying terrains located along the Dead Vistula River. Students experimented on an amphibious zone between land and water developing systems of greenery including new anti-flood parks, and implementing NBS for flood-resilient and liveable public spaces.

DISCUSSION

The involvement of students in the research programme led to the emergence of novel approaches. Firstly, their excellent results based on working in international and interdisciplinary research groups gave inspiration for further educational experimentations in the form of numerous follow-up innovative courses at partner universities. Starting with research-by-design methods developed during the project workshops, and continuing with follow-up courses, groups of students

extended significantly their areas of expertise empowering urban designs with NBS, gaining knowledge on place-making strategies, and building their critical reflection upon the unique characteristics of urban waterfronts. They delved into the science-art-engineering nexus, experienced the virtual representation of nature and learned how to conceptualise and convey their ideas in the text through creative writing about climate futures. An interesting approach visible in almost all inventions produced within offered courses and Master theses was the affirmation of possible changes.

One of the fundamental questions underpinning many of the proposed concepts was how to embrace the uncertainty of flooding and even use the threats of flooding to catalyse discussions about urban relations to nature. For example, the ways in which relations to nature are formulated through exploring wetlands [25] and the space assigned to other species, such as fish living in urban waters [26] when planning for rural and urban regeneration and resilience, as was discussed in the Stockholm context. This question initially concerned the vulnerable marshland territories, but it could be extrapolated into many different settings. As the scenario planning courses reveal, when acknowledging the uncertainty of flooding and designing for this uncertainty - new typologies of built structures and landscapes emerge on the land-water interface (Figure 2 - left). Students proposed original solutions merging environmental perspective and green energy transformation with spatial and social aspects. They delved into artistic concepts of connectivity with the natural element of water and its digital representation in media art.



Figure 2: From conceptual images of urban dystopia to software modelling: waterfront and climate change (l) (author: P.R. Garcia); and calculated run-off retention in cubic meters for Gdańsk with dark blue for high retention and light blue for low retention (r) (author: A. Azadgar).

Experiences derived from the three schools of architecture confirm the emergence of innovative approaches, and also reveal that there is no single solution for interpreting and transforming reality and envisioning the future of urban waterfronts. However, the findings confirm the need to integrate heritage perspective into climate-driven urban transformations, the role of co-creation and the need for critical thinking. Students stipulated the role of NBS and blue-green infrastructure in climate adaptation plans for urban waterfronts as a tool for their regenerative transformation. Indeed, NBS enhance urban liveability and biodiversity, increasing cities' resilience to climate change. They are essential in managing water-related issues in urban areas, such as flooding. This topic, although very promising, demands in-depth explorations - implementing NBS is complex due to the range of ecosystem services, their multifunctionality, and trade-offs between functions, requiring a deeper understanding of their execution for significant outcomes in cities (Figure 2 - right). For this reason, this topic as well as several others related to urban waterfronts in the era of climate change, have been currently explored within the doctorate research of the participants of the SOS Climate Waterfront project.

The presented series of courses developed in a strong linkage with the SOS Climate Waterfront project revealed innovative aspects and approaches that could be implemented in architectural education to face challenges posed by climate change. The findings proposed by students, created on a verge between many disciplines allow for creative insights into the ongoing shift from merely sustainable to regenerative approach in designing for cities. Many of the course results were published in research articles and book chapters, many were exhibited and several received external awards. All this confirms the numerous benefits and efficiency of the proposed research-based architectural education. It should be noticed though, that research-empowered education cannot rely only on the initiatives of involved academics and there is a need for more system-based approaches. A good example of best practices is a recent regulation implemented at Gdańsk Tech that imposes the introduction of a new subject - research project as part of the Master studies curriculum. This could be perceived as an important structural step toward stronger integration of Master students into research tasks.

CONCLUSIONS

The strategy of integrating Master students into international research initiatives leads to research-empowered education. It is one of the operational tools for linking education with cutting-edge research topics. Research projects are by their nature transdisciplinary and developed by international consortia with researchers of different backgrounds, representing complementary disciplines, but also cultural institutions, artists, local municipalities and other stakeholders. The research

tasks supported by international funding agencies are by definition innovative, striving to cultivate new modes of critical thinking and aiming to develop novel solutions. Integrating students into research programmes allows them to reach beyond the usual outlines of the education schemes indicated in the curricula, it boosts creativity and fosters the emergence of innovative approaches. It is important to acknowledge challenges of interdisciplinary dialogues, teams and analysis, but the climate challenges visible on the horizon will require cross-disciplinary solutions. So, new approaches are required. Moreover, this types of initiatives, spanning across academic disciplines, national borders and different geographical conditions, motivate academics towards proposing more creative offers for courses, delving with Master students into attractive thesis topics, and inspire them to chart novel paths for further educational and research objectives and methods.

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BIOGRAPHIES



Lucyna Nyka (PhD, DSc) is a full Professor in the Faculty of Architecture at Gdańsk University of Technology, Gdańsk, Poland. Her research interests focus on historical hydrographies, blue-green solutions for cities, water-related architecture and urban landscapes. She is involved in several transdisciplinary research studies on the urban environment and re-naturalisation of cities. She is the author, co-author and expert in many European research projects, and recently was involved in the H2020 SOS Climate Waterfront project focused on linking research and innovation on waterfront studies to face climate change. She is a member of the Architecture and Urbanism Committee at the Polish Academy of Sciences (PAN), one of the Vice-Presidents of the International Academic Advisory Committee of the World Institute for Engineering and Technology Education (WIETE-IAAC), based in Melbourne, Australia, and a member of the Research Committee

for Valencia International Biennial of Research in Architecture (VIBRArch).



Anahita Azadgar is a PhD candidate in the Faculty of Architecture at Gdańsk University of Technology, Gdańsk, Poland. She received her Master's degree in urban design from Shahid Rajaei Teacher Training University, Tehran, Iran, in 2022, focusing on revitalising waterfront spaces using a socio-ecological approach. She has participated in various workshops associated with the SOS Climate Waterfront project, held in both Rome, Italy and Lisbon, Portugal. Additionally, she took part in the PROMETHEUS H2020 initiative in Pavia, Italy. Currently, her research revolves around nature-based solutions for flood protection in waterfront cities.



Katarina Larsen, works at KTH Royal Institute of Technology, Stockholm, Sweden, where her ongoing research interests are dealing with citizen involvement and co-creation methods in urban climate strategies, studies in the interface between science-policy-making and interdisciplinary science addressing sustainability challenges. She has an academic background in biology, urban studies and regional planning, a doctoral degree from KTH Royal Institute of Technology, and was an international post-doctoral and a visiting scholar at Stanford University, USA (Scandinavian Consortium for Organisational Research) and at Bocconi University, Italy. Her ongoing research projects address the transition towards more sustainable mobility services, and climate utopias and dystopias in an urban context. Her ongoing commissions of trust at the KTH School of Architecture and the Built Environment include the coordination of Science Impact Talks (SIT) focusing on the

development of tools for popular science writing and organising creative writing workshops together with the KTH Climate Action Centre and the Environmental Humanities Laboratory inviting students to creative writing on urban climate futures.



Pedro Ressano Garcia is an architect specialising in waterfront urban design, with a career that integrates research, teaching and practice. Pedro Garcia began teaching at the University of California, Berkeley, USA, in 1996 and has held prominent roles, such as Head of the Department of Architecture and Urban Planning at Universidade Lusófona in Lisbon, Portugal. He currently teaches at Laval University, Quebec, Canada, and coordinates the H2020 MSCA-RISE initiative, focusing on resilience and climate change for waterfronts. Pedro Garcia is the author of *Tagus Platform - Back to the River, Lisbon's Waterfront and the 21st Century*, and has edited six books on waterfront urban design. He has received numerous grants, including from the Calouste Gulbenkian Foundation, and won the Pancho Guedes Architecture Award in 2010. His Lisbon-based office, Ressano Garcia Arquitectos, merges theory and practice in projects that emphasise cultural value, earning accolades like

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