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Community climate resilience and environmental education: Opportunities and challenges for transformative learning

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ABSTRACT

Grassroots initiatives towards climate resilience in cities are likely to embed environmental education practices with potential transformative impact among young people. Through interviews and document review, we examine two initiatives involving different non-formal educational actions in Barcelona: a civic ecology practice based on the community gardening of tree pits and an energy citizenship project with the school community. Despite their diverse nature and outcomes, these educational actions promoted by grassroots groups intend to boost young people's critical reflection, responsibility, and agency for taking individual action towards more climate-resilient cities. However, connections between agency, empowerment and transformative learning become more challenging when translated to the collective. Limitations relate to the lack of effective engagement approaches that reinforce social connectedness and local identity, and insufficient evaluation strategies. By discussing these potentials and challenges, we shed light on the synergies concerning transformative learning between the fields of environmental education and urban community resilience.

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Agency; community resilience; climate change; non-formal education; youth

Introduction

Many city councils worldwide have made climate emergency declarations and developed climate adaptation plans while embracing resilience as a goal or process (Meerow, Newell, and Stults 2016; Moser et al. 2019). Urban resilience can be understood as: "the ability of an urban system -and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales- to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" (Meerow, Newell, and Stults 2016, 45). Based on this broad approach, academics have identified that beyond government actions, grassroots responses to environmental changes, including disasters and other climate impacts, can be understood as community-led resilience initiatives (Berkes and Ross 2013; Cutter et al. 2008; Magis 2010). Indeed, cities emerge as a critical arena for community resilience to flourish and stand in a context of increasing awareness and action

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over the climate emergency (Bródy et al. 2018; Cloutier, Papin, and Bizier 2018; Goldstein 2008). Environmental education can contribute to such grassroots mobilization through projects fostering youth agency and empowerment to take climate action within their local communities (Trott 2020).

Community climate resilience encompasses diverse practices relying on community resources that their members mobilize to cope or adapt to climatic changes while navigating uncertainty (Magis 2010). Urban green infrastructure and agroecology projects, bioclimatic housing, sustainable mobility experiences (e.g. communal bike garages), and energy consumers' cooperatives are examples of such climate resilience initiatives led by grassroots organizations (Bródy et al. 2018). Environmental education actions are arising from these initiatives in the form of training courses, field trips, or debates, among other formal and non-formal learning experiences. Unraveling these educational actions and understanding their pedagogical approaches, intended audiences, and expected outcomes, as well as the challenges they face, can shed light on how the fields of environmental education and urban community resilience can enrich each other.

This article contributes to previous work on elucidating the intersections between environmental education and urban community resilience, which has been mainly developed in North America. Earlier research has examined how expert-designed environmental educational practices linked to urban gardening, watershed restoration, or disaster response contribute to leverage social-ecological resilience attributes such as diversity and social learning (Krasny and Roth 2010; Krasny and Tidball 2010; Smith, DuBois, and Krasny 2016); or how environmental education programs define and address resilience and adaptation when dealing with climate disasters (Dubois and Krasny 2016; Krasny and DuBois 2019). Other research in the UK has looked at how international organizations use resilience approaches, tools, and methods to promote learning to deal with climatic challenges (Boyd and Osbahr 2010).

This study mainly focuses on the transformative potential of educational practices linked to climate resilience initiatives led by grassroots organizations, which are still unexplored, especially in the Southern-European context. We first examine the conceptual foundations of these intersections and underlying processes from both learning and resilience theories. Then, we explore such intersections through two community-led climate resilience initiatives that implement educational actions with young students in Barcelona: one on civic ecology and the other on energy citizenship. Civic ecology is an approach in environmental education that addresses the study of the outcomes and learning situated in those "environmental stewardship practices in which community members join together to restore and manage local resources" (Tidball and Krasny 2011, 4). Energy citizenship is a concept developed out of the environmental education realm but applicable to the field because it epitomizes people's active involvement in the energy transition through learning processes, that include educational activities (Campos and Marín-González 2020), by emphasizing "awareness of responsibility for climate change, equity and justice" (Devine-Wright 2007, 72). The exploration of these non-formal climate action education initiatives is relevant in Barcelona where the school curricula do not properly address climate change till secondary education. The Catalan curricula and contents for primary education do not mention the term climate change and only address issues related to climate education in one subject (i.e. social sciences) in the last two years of primary education (Catalan Government 2017). Finally, we discuss our findings regarding the opportunities and challenges of grassroots resilience initiatives for transformative learning and empowerment to foster climate action while highlighting the synergies between environmental education and urban community resilience.

Conceptual overview

Environmental education and social-ecological resilience

The interlinkages between environmental education and resilience to climate change in urban settings have been often studied from the need to understand how environmental education

programs, particularly those linked to stewardship practices, can contribute to building resilience from an integrated, social-ecological systems perspective (Berkes, Colding, and Folke 2003). Considerable work has been done from the civic ecology approach in the USA and Canada. Krasny and Tidball (2010) analyzed resilience attributes (e.g. diversity, self-organization) using evidence from environmental education programs implemented with young people in community gardens and relying on situated learning theory. This theory describes learning "as moving from an inexperienced to a skilled individual in authentic social and environmental practices" (Krasny, Tidball, and Sriskandarajah 2009, 2), being situated learning "an integral part of generative social practice in a live-in world" (Lave and Wenger 1991, 35). Their findings on diversity, for instance, showed that program activities engaged youth in learning from elderly gardeners through their knowledge about local plants while combining such practical experience with school science learning. Such environmental education programs assembling diverse knowledge emanating from different sources, they argued, can support the resilience of the system by expanding the options to enable adaptation in the face of disturbances such as food insecurity. This finding is in line with ethnoecological research suggesting that the diverse body of knowledge present in and conferring resilience to home gardens results from different transmission pathways (Calvet-Mir et al. 2016). Moreover, the study of Krasny and Tidball (2010) on the environmental education programs identified some elements of the self-organization attribute, understood as "the emergence of larger-scale patterns from independent smaller-scale processes" (ibid, 474). These authors argued that, by engaging young people in participatory learning, the studied programs transitioned from individual learning to community-level outcomes such as social connectedness that may mobilize others' learning and community action. Also related to the self-organization attribute, but with different results, Mitchell et al. (2015) study showed that young people increased their knowledge and awareness of energy efficiency through an environmental education program but that the program was less effective in engaging their parents and in fostering intergenerational learning.

Social learning, as a resilience attribute, has also been addressed by civic ecology research. Social learning is defined as a process of collective, iterative reflection resulting from the sharing of knowledge through learning-by-doing (Armitage, Marschke, and Plummer 2008), and it is capital for community resilience (Berkes and Ross 2013). In the context of hurricane and flooding restoration projects, Smith, DuBois, and Krasny (2016) assessed whether and how three different civic ecology-related education programs boosted social learning by capturing changes in related processes and outcomes. In general, all three programs offered activities such as community planning workshops or restoration of trails that fostered communicative processes relying on information sharing and collaborative problem-solving among young students and some opportunities for reflection and deliberation. These stewardship and restoration activities also seemed to change the way participants visualized the disturbances: from the impacts of a past event to a set of mitigation and adaptation responses in the face of future events. Similarly, Krasny and Roth (2010) found that those students involved in an environmental education program of a watershed restoration project improved their skills and gained different knowledge to address watershed issues in the face of change through hands-on methods and interacting with diverse community members. These authors relied on activity theory and social-ecological resilience to explain these findings. As it does the resilience literature, activity theory emphasizes change and adaptation (Berkes, Colding, and Folke 2003; Folke et al. 2010). Activity theory focuses on how contradictions and disruptive elements shape learning processes that stem from the interaction between learners and other social actors and their biophysical environment (Krasny and Roth 2010). Such learning processes resulting from the combination of diverse perspectives can increase both students' and community's adaptive capacity and thus foster resilience (Pahl-Wostl 2009). Krasny and DuBois (2019) argued that some environmental education programs based on the civic ecology approach engaged students in climate adaptation education through hands-on, participatory restoration activities that promoted learning and

reflection while connecting them with nature and improving their action for adaptation. On the topic of energy citizenship, promoting students' reflective learning via collaborative educational interventions was observed and assessed by Petrova, Torres Garcia, and Bouzarovski (2017). These authors conducted participatory action research with undergraduate students that focused on solving the problem of inefficient energy consumption in close collaboration with local businesses, charities, and advocacy groups. These authors found that students increased their awareness of the situation while improving their critical thinking, problem-solving and collaborative skills due to their active engagement in this action research intervention.

Furthermore, environmental education linked to climate change, and civic ecology, in particular, has expanded to incorporate social-ecological resilience elements into their programs. After Hurricane Sandy in New York City, Dubois and Krasny (2016) found that environmental educators changed and adapted their practice by establishing links between green infrastructure design and community engagement to reduce flooding impacts in the event of future storms. However, Krasny and DuBois (2019) recognized that these programs did not provide students with opportunities to make relevant decisions on what to learn and how to do it. The educators had the "control" over the intervention, as documented in some other environmental education experiences (Jickling et al. 2018). The study mentioned above of Smith, DuBois, and Krasny (2016) also identified the lack of flexibility and inclusiveness in the formulation of the restoration challenges to be addressed, as deterring participants from creating a sense of ownership, engaging in negotiation, and increasing self-determination. These identified barriers may undermine their reflection, interaction, and participation in other collective learning processes beyond social learning (Armitage, Marschke, and Plummer 2008). In this regard, it has been suggested that social design experiments that rely on the notions of resilience, transformation, and equity can support learning environments "in which participants can become designers of their own futures" (Gutiérrez 2016, 192). In these experiments, the diversity of participants' profiles and the different tools and forms of engagement used can lead to collaborative interactions in a playful environment and foster participants' imagination and agency for thinking about the future by changing current understandings and practices (ibid).

The development of flexible learning abilities entails accepting a diversity of perspectives and values and the promotion of critical and reflective thinking, which enhances adaptive capacity (Fazey et al. 2007). Further, critical reflection on the ways individuals perceive, understand and position themselves concerning their experience and action is also important to foster transformations in their frames of reference, that is, a transformative learning process, which should lead to conscious changes in attitudes, behaviors and social norms (Mezirow 1997). Transformative learning can support community adaptation to climate change by empowering local people to take action for change (Quang and de Wit 2020). Indeed, agency and self-organization have been identified as critical attributes needed to promote community resilience and transformative learning (Aguilar 2018; Berkes and Ross 2013; Krasny and Tidball 2010). In what follows, we proceed to examine these two concepts in terms of their potential synergistic contribution to the field of environmental education.

Community resilience to climate change and transformative learning

From the perspectives of social-ecological systems thinking and psychology, community resilience to climate change goes beyond immediate disaster responses and embraces conscious actions addressed to influence the course of environmental and social change (Berkes and Ross 2013; Maclean, Cuthill, and Ross 2014). As argued by Magis (2010, 402), "members of resilient communities intentionally develop personal and collective capacity that they engage to respond to and influence change, to sustain and renew the community, and to develop new trajectories for the communities' future." In this line, social-ecological resilience can be articulated by

grassroots climate adaptation initiatives as an approach for fostering the transition to more sustainable and socially just societies (Cretney 2014).

Previous literature has identified relevant community attributes that need to be activated to build community resilience shaping transformative change. For instance, the individual and collective capacity to act (i.e. active agency) and the ability for self-organization to operate as a group are two main requirements for taking action towards climate adaptation and transformation collectively (Berkes and Ross 2013; Brown and Westaway 2011; Goldstein 2008; Magis 2010). Agency and self-organization, in turn, depend on other community resilience attributes such as community infrastructure and resources, equity in access and distribution of these resources, leadership, sense of place and identity, values and beliefs (e.g. acceptance of change), social networks, local knowledge, and social learning, among others (Berkes and Ross 2013; Norris et al. 2008).

Focusing on learning processes linked to global environmental change issues, including climate change, becomes particularly appropriate to improve the understanding of the intersections between the fields of environmental education and resilience (Schultz and Lundholm 2010; Sterling 2010). In this vein, Krasny, Lundholm, and Plummer (2010) advocate for cross-disciplinary approaches that can unravel the interlinkages between learning and social-ecological resilience theories to enrich the field of environmental education research by transferring relevant notions such as change and transformation. As mentioned above, efforts in environmental education research have been mainly addressed to examine and discuss situated and social learning processes linked to community resilience attributes and correspondent interventions for educational purposes (Krasny, Tidball, and Sriskandarajah 2009; Tidball et al. 2010; Smith, DuBois, and Krasny 2016). In contrast, the potential interlinks between transformative learning and community climate resilience have been less approached.

As Sterling (2010) suggests and discusses, transformative learning theory can enhance the capacity to contribute to social-ecological resilience in the face of uncertainty and unexpected disturbance by leading to a conciliatory environmental education approach between its two main contrasting paradigms: i.e. instrumental and intrinsic. While the more traditional instrumental view entails a normative dimension linked to the promotion of desired behaviors towards sustainability, the intrinsic view puts the learner at the center of the learning process by following Dewey's and Bruner's constructivist ideas on grounding learning in real experience, dialogue, and reflection to make informed decisions (Bruner 1960; Dewey 1916). Differently from the instrumental view, the intrinsic paradigm considers that learners' decision on further adopting more pro-environmental behaviors or not is altogether secondary: "From an intrinsic educator's point of view, it is much more defensible to educate the critical thinker who can then make informed decisions than to educate for any kind of desirable direction (or away from an existing state), which might possibly open up accusations of ideological orientation" (Sterling 2010, 514).

Despite such epistemological and methodological differences, it is argued that both views of environmental education and learning experiences (i.e. instrumental and intrinsic) can be seen as complementary under the lenses of transformative learning and in the context of community resilience (Armitage, Marschke, and Plummer 2008; Sterling 2010). To achieve that, Aguilar (2018) calls for moving from Mezirow's (1997) understanding of transformative learning focused on the individual towards a learning approach that can inform group learning processes fostering environmental action. As social and situated learning, transformative learning requires task-oriented and problem-solving actions linked to the community providing content and acknowledging the need for a behavioral change (Krasny and Tidball 2010; Smith, DuBois, and Krasny 2016). However, it is precisely the collective capacity to move from critical reflection to responsible action when guided by the reinterpretation of meanings and values, making transformative learning different from these approaches (Armitage, Marschke, and Plummer 2008). In this sense, transformative learning requires space for individual and collective reflection to

revise pre-established mental models and experiences for becoming more critically aware and socially responsible of one's assumptions in the face of disturbing and unexpected events such as climate uncertainty (Mezirow 2000; Aguilar 2018). Transformative learning also requires validating contested beliefs in discourse, which includes improving self-efficacy beliefs, and further engaging in taking action (Mezirow 1997). Therefore, and although instrumental and individualistic approaches focusing on learning outcomes have dominated the historical trend in environmental education (Rickinson, Lundholm, and Hopwood 2009), putting more attention on learning processes at the social level is increasingly recognized as crucial for connecting the field of environmental education with community resilience. In this line, it can be argued that the normativity of the instrumental view when educating "for" sustainability should be overcome because it implies the acceptance of a stable, known state of desired sustainability, which is in contradiction with the dynamic and unpredictable nature of social-ecological systems according to the social-ecological resilience theory (Folke et al. 2010). Navigating such an integrated view of environmental education and community resilience through transformative learning processes can thus challenge individual and collective assumptions about how things are and can be while fostering collective agency for acting on issues participants define as crucial for their lives and communities (Aguilar 2018; Sterling 2010).

To deepen into how these interlinkages between environmental education, community climate resilience, and transformation are understood and put into practice by the grassroots, we examine two community-led climate resilience initiatives in the city of Barcelona (Spain) with a strong educational component and with potential transformative impact. In particular, we look at the different educational actions embraced by these initiatives to understand their pedagogical and engagement approaches and related challenges, focusing on community resilience attributes and transformative learning processes. In doing this, we examine how environmental education contributes to, and at the same time is enriched by, these community initiatives promoting urban climate resilience.

Methods

Description of community-led resilience initiatives embracing educational actions in Barcelona

Barcelona, located in the Northeast part of Spain on the Mediterranean Sea, is the second-largest city in Spain, with a population of 1.66 million inhabitants (Idescat 2021). Barcelona is well known for its ambitious approach to climate change co-production policies and the active role of grassroots in promoting actions related to urban sustainability and, more specifically, climate change adaptation and mitigation (Satorras, Lara, et al. 2020). The City Council has developed an ambitious Climate Action Plan and a Climate Emergency Declaration for the period 2018–2030 (Barcelona City Council 2018, 2020), which identifies the climate change challenges for the city (e.g. rising temperatures, reduced availability of freshwater, among others).

We developed a four-step approach to select the two community-led climate resilience initiatives embracing educational actions. First, we conducted an extensive screening to identify the diversity of climate change actions, movements, and strategies of citizen groups and organizations addressing the most relevant hydro-climatic risks in the city exacerbated by climatic change: heatwaves, floods, and droughts. As a result, 27 initiatives were identified and compiled (Satorras, Lara, et al. 2020). Second, we classified these initiatives based on their goal, as i) urban greening projects, ii) actions to guarantee access to energy and/or water, and iii) environmental awareness-raising activities. Third, we identified those initiatives implying some educational intervention, from occasional informative talks to long-term projects (i.e. 14 out of 27), and amongst these, those exclusively targeting young people and implemented in collaboration with schools (i.e. 7 out of 14, all corresponding to urban greening projects and actions for energy/water access). And fourth, we selected one illustrative initiative within each type.

Consequently, the two chosen initiatives embrace diverse climate resilience topics and goals covered through different non-formal educational actions (summarized in Table 1) and have different geographical scope within the city: one is located in a central district of Barcelona, and the other unfolds in two working-class neighborhoods (see Figure 1). Regardless of being developed within school environments, both are considered community-led initiatives because they are conducted by grassroots organizations leading bottom-up projects and solutions for responding to climate change challenges faced by local communities (Seyfang and Smith 2007).

The first initiative, *community gardening of tree pits*[1], illustrates grassroots organizations' efforts to deal with hydro-climatic risks in the city by implementing green infrastructure projects and other greening interventions (Satorras, Lara, et al. 2020). In 2018, the grassroots Espai Ambiental Cooperativa, started this collaborative project in close collaboration with the Barcelona City Council through a co-managed environmental education service (*Aula Ambiental Sagrada Família*). The project was developed in the *Dreta de l'Eixample*, an affluent neighborhood located in the center of the city (*Eixample* district), but one of the zones with the lowest urban green space per capita (0.59 m2/inhabitant, Barcelona City Council 2017). Local primary school children (8-10 years old) and several shops were engaged in gardening selected tree pits in a shopping and residential street with heavy traffic (*Carrer* Girona). This community-led climate resilience project relied on evidence showing that tree pits gardening contributes to naturalizing cities while reducing the volume of stormwater runoff (Grey et al. 2018). Retaining stormwater runoff is a recurrent challenge in Barcelona that has been worsened because of the increase of extreme rainfall events in the last years (Barcelona City Council 2018; Nóblega Carriquiry, Sauri, and March 2020).

The second initiative, *E3: energy empowerment at schools* (in Catalan, *Empoderament Energètic en centres Educatius*), shows the collaborative work led by the grassroots El Risell to increase thermal comfort and energy savings (Satorras, Lara, et al. 2020) through an educational intervention with secondary school students from disadvantaged neighborhoods. Between 2017 and 2018, and in close collaboration with other cooperatives and with the support of municipal agencies, the *E3* project was piloted in three public secondary schools from the working-class districts of *Sant Martí* and *Sant Andreu*. To test the project with students from different age groups, two schools involved students from various secondary grade levels. The third one

Table 1. Description of the community-led climate resilience initiatives and corresponding educational actions.

Community-led climate resilience initiative	Community gardening of tree pits	E3: Energy empowerment at schools
Educational action	Gardening of tree pits in Carrer Girona, Eixample district	Pilot E3 project in Sant Martí and Sant Andreu districts
Leading grassroots organization	Espai Ambiental Cooperativa (a non-profit worker's cooperative of 7 members with broad experience in community, socio-environmental projects)	El Risell (a non-profit worker's cooperative of 8 members with strong expertise on housing and energy from a critical perspective and tightly linked to social and environmental issues)
Other organizations involved	Parks and Gardens municipal department (Urban Ecology Dept., Barcelona City Council)	Aiguasol and Tarpuna cooperatives; Barcelona More Sustainable Schools Network; Barcelona Education Consortium; Barcelona Energy Agency
Engaged actors	About 70 primary students and ten teachers from Sagrat Cor and Inmaculada Concepció schools (charter schools: privately owned schools with partial public funding); 7 shops from the Cor Eixample association (association of retailers and professionals); Dreta de l'Eixample neighborhood association; Sofia Barat Library	About 400 students and 16 teachers from Institut Doctor Puigvert, Barri Besòs, and Rambla Prim secondary schools (public schools); students' parents and other neighbors
Duration	Two months each year (2018-2019)	Ten months (2017-2018)

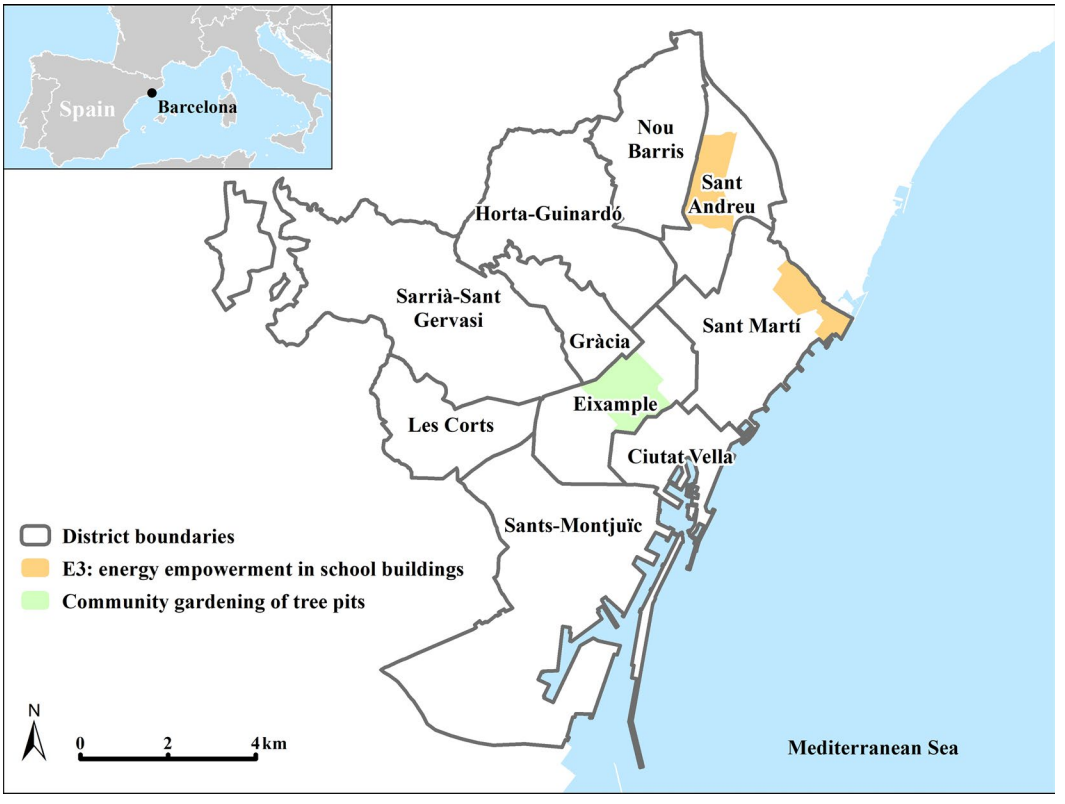

Figure 1. Location of the analyzed community-led climate resilience initiatives in Barcelona.

engaged a group from vocational training. Previous evidence has shown that energy citizenship projects at schools, such as the *E3* one, can enhance resilience to cope with heatwaves by raising students' and teachers' awareness of the school and classroom thermal conditions and generating knowledge about how to manage energy efficiently at both school buildings and home (Mitchell et al. 2015).

Data collection and analysis

The UOC's Ethics Committee approved the study in October 2019. We gathered empirical evidence from semi-structured interviews conducted with three representatives of the two community-led climate resilience initiatives in September and October 2020. Interviewees' perspectives were triangulated with the revision of existing information at the webpages and social media channels of the involved grassroots organizations and the testimonies on the educational actions collected in public and non-public reports, local news, and podcasts. This revision took place between June and October 2020.

We implemented interviews online because of the COVID-19 pandemic. To select the interviewees, we first reached out to the people responsible for each organization leading the studied community-led initiatives, based on data previously gathered by the authors (Satorras, Lara, et al. 2020). If they were directly involved in the educational activities, we asked them for an interview. If not, they send us to their colleagues leading the educational intervention in each organization. Selected participants to be interviewed were involved in the research voluntarily and were given the project's informed consent form that included information on the project's aims and methods, the implications of the study, and the nature of their participation.

Interviewees' (oral and written) consent was obtained before the interviews. We then conducted two interviews with them: the two members of Espai Ambiental Cooperativa involved in the *community gardening of tree pits* project (an environmental scientist and a sociologist with broad expertise in non-formal education), and the member of El Risell leading the *E3* initiative (an architect specialized in sustainable building with educational vocation). Interviews were conducted in Catalan, with an approximate duration of 45 min each. They were video-recorded (as they were the consent from the interviewees). We used the following guiding questions: 1) What is the educational action implemented in the context of the climate resilience initiative about?; 2) Why are you conducting this educational action?; 3) What are your targeted audiences?; 4) Which is/are the main purpose/s you aim to achieve?; 5) Do you expect to promote any change?; 6) Are you reaching your expectations?; and 7) What challenges are you facing?

We found seven secondary information sources: the two webpages of the cooperatives leading the projects (https://aulambiental.org; https://elrisell.cat), their Twitter channels, a public report (AMB. 2019), an internal report (Risell and Tapurna 2019), and news on the local media (Betevé 2019).

Interviews and the testimonies of other informants found in secondary information sources were transcribed, and data were anonymized at the individual level, so an identification code was assigned to each interviewee and informant (participant organizations were not anonymized at their request). Data were analyzed through conventional content analysis by developing a set of codes and subcodes and using the software Atlas.ti. Five codes were created a priori from reviewed literature on the interlinkages between transformative learning and community climate resilience theories in which situated learning and other learning approaches are also relevant (Krasny and Tidball 2010; Sterling 2010; Smith, DuBois, and Krasny 2016; Berkes and Ross 2013; Aguilar 2018). These pre-defined codes were: 1) pedagogical and engagement approaches, 2) implementation challenges, 3) community resilience attributes (including agency, self-organization, local identity, social learning), and 4) transformative learning processes (including problem-solving, reflection, critical awareness, responsibility, empowerment).

Methodological limitations

The Covid-19 pandemic conditioned the development of this research. Since early 2020, the grassroots stopped their activities, and the schools were closed due to confinement measures and subsequent restrictions. As a result, our analysis mainly relies on the testimonies of the grassroots organizations involved in the educational actions. To minimize biases in research results, we triangulated interview data by revising secondary sources of information. Nevertheless, and aware of these data collection constraints, the research was not conceived as an impact assessment of the learning outcomes resulting from each selected initiative, nor as a comparative exercise, but as an explorative study to provide an overview of the transformative potentials (and challenges) of the educational practices linked to two different community-led resilience initiatives in the city of Barcelona. Results should be interpreted with caution in this regard.

Results

Community gardening of tree pits

As explained by one of the interviewees (informant #1), this initiative mostly relied on the pedagogical strategy of service-learning to greening local streets through hands-on activities engaging primary school students and the whole neighborhood in the gardening of tree pits. Service-learning is a form of experiential learning based on critical reflection that combines academic learning with voluntary service in the community, so both students and the

community can be benefited (Deeley 2010). It is thus linked to situated and project-based learning. The cooperative implemented a series of workshops in close collaboration with the teachers involved and with the support of the local flower shops. Workshops were about selecting the best plants for the tree pits taking into account plant-climate relations and local varieties, and how to engage residents in taking care of the planted tree pits while producing informative posters. In the words of an involved educator, these activities were designed "to raise children's awareness of the need of greening urban spaces to improve people's physical and emotional well-being through local, small actions that recover typically undervalued public spaces" (informant #1). By selecting the tree pits to be planted, the cooperative promoted the early engagement of both children and local retail shops in the initiative. Students identified those tree pits in the street with the most appropriate size to be planted while finding out those salesmen in nearby shops who were more willing to get involved in the project and take care of the plants. Further, and as a non-planned activity, the cooperative also engaged a group of secondary school students at the request of their teacher because they were studying a lesson about sustainability and climate change. These students helped the youngest ones to sow the tree pits with the selected plants (Figure 2). In turn, maintenance tasks such as watering the plants and cleaning the pits were organized to engage both kids and interested neighbors, and gardening tools and material (e.g. shovels, potting soil, plants, gardening books) were available at the local library (Betevé 2019). As mentioned in the initiative web page (Aula Ambiental 2020),

Figure 2. Images of the analyzed community-led climate resilience initiatives. Source: (top) Espai Ambiental Cooperativa, (bottom) El Risell.

promoting such collaborative interaction between schools, retail shops and local entities in the neighborhood, and the local government, was perceived as a fundamental cornerstone of the project.

Despite students' interest and subsequent actions with the library, local shops, and other neighbors, unfortunately, the cooperative had to cancel the project due to vandalism. Most of the plants were stolen, even some of the signs disappeared. One of the educators explained that the causes were not yet known: "we don't know if it was just because of acts of vandalism, or people who took the plants for their houses or someone who was against the greening of these spaces" (informant #2). They also explained that a similar project worked well in *Trinitat Nova*, wherein a group of neighbors planted, managed and took care of tree pits in one of the streets for more than two years. They argued that this success could be because *Trinitat Nova* is a working-class neighborhood (located in *Nou Barris* district) with more robust social networks and shared identity than *Dreta de l'Eixample*. Based on this example of good practices, the educators were rethinking the project to prevent such a situation in the future at the time of the interview.

Two community resilience attributes emerged from our data: agency and local identity. Interviewed educators argued that "children are effective agents for transformation" (informant #2) and explained that the tree pits project focused on realizing such potential by promoting students' self-efficacy beliefs: "we consider that children are a social group with rights and agency, so we leave aside the paternalistic approach of *Come here that I'm going to teach you* and we focus on *I'm going to explain it to you and then you will decide what to do and I'll help you*" (informant #1). But, as mentioned before, they also argued that strengthening local identity and social networks was necessary to guarantee the initiative's success in the long term in the *Dreta de l'Eixample* neighborhood. This neighborhood has become more business and touristic-oriented, and the local population has been displaced due to gentrification (AVVDE. 2018). In such a context, they recognized the need to implement an awareness-raising campaign at the neighborhood level to ensure neighbors' engagement before starting the activities with the students.

Reflection and critical awareness were two elements identified as underlining transformative learning processes. One of the cooperative educators in charge, when interviewed on local television, explained that workshops fostered kids' discussion and reflection about the social-ecological importance of urban green spaces, particularly in the context of their neighborhood - *Dreta de L'Eixample* - where green areas are limited (Betevé 2019). Both educators (informants #1 and #2) acknowledged that the impact of the project was not formally evaluated. Still, they perceived that it actively engaged participant children in reflection on the need to green the city and, in some cases, made them more environmentally aware and responsible for their daily actions. The initiative also sought to empower children to undertake responsible environmental action in their community: "with our guidance, participant children organized themselves to water the plants and clean the tree pits in the coming months" (informant #2). However, vandalism over the tree pits led to kids' frustration, thus limiting the initiative's impact in this regard. As perceived by the interviewees: "participant students got the impression that no matter how much effort they put in [the project], anyone at all can come and ruin everything" (informant #1). Educators argued that such frustration was a huge barrier to foster children's agency on climate action and recognized that they were still looking for the best solution: "we need to find the way to deal with their frustration; we need to find the way to make them [participant students] understand that if we all come together, we can change things" (informant #1).

E3: Energy empowerment at schools

The *E3* project was a pilot educational experience on energy citizenship within the school environment and beyond (i.e. the neighborhood) that relied on situated, project-based, and service-learning approaches. With the support of an education expert and participant secondary

teachers, the organizations involved designed a set of activities to increase students' knowledge of the concept of energy and make them aware of how to improve the efficient use of energy at the school and their homes (Risell 2017). These activities included experiments at the laboratory, such as constructing an energy consumption measuring device, and classroom explanations and discussions about related topics such as how architectural features of the school buildings can condition energy efficiency (Figure 2). The cooperative member interviewed (informant #3) explained that students also implemented follow-up activities with their families at home, through which they applied acquired knowledge on energy-saving and thermal comfort at the domestic level. These follow-up activities also included street-level workshops addressed to neighbors in which students shared with them their learnings on enhancing the efficient use of energy.

The cooperative member interviewed (informant #3) highlighted that working in such a disadvantaged socio-economic background was challenging. Some of the activities could not be fully completed in one school because several students who commonly showed negative attitudes towards schooling were reluctant to participate at the beginning of the project. Even so, the results of a post-survey with participant students and teachers indicated that, in general, students' knowledge, attitudes, and interest in energy-related topics were perceived as qualitatively higher at the end of the project (Risell and Tapurna 2019). Yet, it is not possible to know whether such results were related to their participation in the project due to the lack of data collected before the *E3* project activities.

The *E3* project emphasized community resilience attributes related to youth agency in climate action and self-efficacy beliefs. The interviewed member of the cooperative stated that: "our main priority is achieving that people can live in comfort while minimizing energy consumption. (…) We aim to inform students and also other citizens that energy and housing are fundamental rights. Even though oligopolies speculate about their prices and that it is difficult to change things at this level, we emphasize that '*you' as a citizen* can do something to make a change" (informant #3). Indeed, some students actively participated in the workshops conducted in their neighborhoods and identified themselves as "neighborhood energy agents" (Risell and Tapurna 2019). Despite the impact of the activities beyond the school facilities was not formally evaluated, the cooperative member explained that these workshops "were well-received by the neighbors, such as those explaining what the electricity bill is telling in terms of the different parameters included in it, and those they need to look at more closely to reduce electricity consumption" (informant #3). However, the cooperatives leading the project acknowledged the need for reinforcing those activities relying on the service-learning approach to improve community action in this regard (Risell and Tapurna 2019). As a result of this pilot project, other metropolitan municipalities have adapted the *E3* project activities to primary education while strengthening the focus on the service-learning approach to maximize their impact beyond the school, i.e. at home and the community levels (AMB. 2019).

Regarding transformative learning processes, the designed set of activities was conceived to emphasize students' critical reflection, awareness, and action towards improving the efficient use of energy at their school and community. Survey results showed that students acquired enough knowledge to be aware of energy consumption challenges and perceived themselves as having more tools to help their families understand energy use at home due to their involvement in the *E3* project. Similarly, participant teachers reported that the students were able to assess the energy performance of the school buildings primarily in an autonomous way. As mentioned in the cooperatives' report, the fact that some students called themselves "neighborhood energy agents" was understood as an indicator of their empowerment (Risell and Tapurna 2019). The cooperative member interviewed also perceived the pilot project upscaling at the city level as an indicator of success. In particular, the activities have been re-designed in close collaboration with voluntary teachers belonging to the *Barcelona More Sustainable Schools Network* to implement a reduced version of the *E3* project with the secondary schools belonging to this network.

Discussion

By analyzing these two community-led climate resilience initiatives embracing educational actions in Barcelona, we have examined the pedagogical and engagement approaches behind them, how young students and other community stakeholders were involved, and the potentials and limitations for addressing community resilience and transformative learning. In what follows, we discuss the main opportunities and challenges of these experiences to foster youth empowerment and climate action while emphasizing the synergies concerning transformative learning between urban community resilience and environmental education.

One of the most relevant potentials shared by both initiatives is that, despite their different activities and topics covered, they aim to boost young people's agency for shaping transformative change towards more climate-resilient urban communities. Agency is a crucial commonality underlying community resilience and environmental education approaches for promoting empowerment and transformative learning (Aguilar 2018; Berkes and Ross 2013; Norris et al. 2008). We have documented how these initiatives actively engaged young students in gardening tree pits in a nearby street and rethinking the use of energy at their schools and homes through reflective and interactive processes of learning. Reflection and collaboration are thus crucial for youth's active engagement in climate action, as other civic ecology and energy citizenship actions have shown (Krasny and DuBois 2019; Petrova, Torres Garcia, and Bouzarovski 2017). The sharing of knowledge and promotion of reflective learning between multiple community stakeholders, in the context of both formal and non-formal education, has also been identified as relevant for building individual and collective adaptive capacities, highlighting the potential contribution of environmental education to social-ecological resilience in this regard (Boyd and Osbahr 2010; Krasny 2009; Lundholm and Plummer 2010). Interestingly, the studied community-based initiatives in Barcelona differed from the above-referred educational actions (Krasny and DuBois 2019; Petrova, Torres Garcia, and Bouzarovski 2017) in that they mainly followed a service-learning approach. Based on this approach, both initiatives tried to equip young students with knowledge and skills to take individual and collective action at the local level and, more importantly, to make them realize that environmental responsibility does not only lie within governments or corporations but also with citizens (or future citizens) like themselves who should be able to have a decisive stake in the management of their environment. Such a focus on strengthening self-efficacy, that is, people's confidence in their ability to manage and control their daily-life situations, is necessary to promote agency and transformative learning (Bandura 1989; Mezirow 1997). As highlighted in the field of the climate change education literature, in particular, transformation depends not only on acquiring more knowledge and values but also on attributing conscious responsibility to students to potentially empower them (Reid 2019).

Also, on students' agency, it is relevant to discuss the implications of the acts of vandalism in the analyzed civic ecology project *(*i.e. *community gardening of tree pits*). As perceived by the interviewees, such unfortunate events resulted in students' frustration and would have had a demotivating effect on them. This result suggests that agency has an emotional dimension that adds to the cognitive, social, and structural aspects highlighted by the community resilience literature (Berkes and Ross 2013; Brown and Westaway 2011; Magis 2010). Environmental education research has analyzed such emotional dimension from the agency thinking, or the motivation to reach the desired goal, that it is embedded in the concept of hope (Ojala 2012). This study (ibid) with teenagers in Sweden showed how their hope concerning climate change positively impacted their pro-environmental behavior and concluded that hope is a motivational force. Thus, it is possible that the civic ecology project in Barcelona created a feeling of hope among students that contributed to their active engagement and that, because of vandalism, they became discouraged and lost hope with negative consequences in terms of agency. Unfortunately, we do not have the data to provide an answer, but further studies can rely on the questionnaires used by Ojala (2012) to compare reported pro-environmental behavior and hope concerning climate change before and after the act of vandalism. Moreover, focus groups

or group interviews with participant children and adults can be organized to find out how these acts of vandalism impacted students' hopes, fears, behaviors, and, consequently, on their agency, but also as a means to deal with their frustration by sharing their emotions and reflecting on them collectively (Nairn 2019). Community resilience and related climate resilience initiatives and educational actions targeting young people can benefit from a better understanding of the emotional aspects linked to youth agency that is being explored by environmental education research.

When translated from the individual to the collective, connections between agency, empowerment and transformative learning emerging from our findings become more blurred and challenging. The emergency of collaborative patterns resulting in a community of practice is related to the capacity for self-organization, which is another critical element for transformation found in both social-ecological resilience and environmental education literature (Elmqvist et al. 2019; Kransy and Tidball et al. 2010). The literature on civic ecology practices has documented how resulting physical changes in the urban landscape leading to environmental improvements, such as greening projects, can further empower other community members to conduct similar actions in the future (Krasny and Snyder 2016). However, upscaling is challenging because there are non-scalable elements that necessarily imply changing mainstream frameworks and rationalities and because it may lead to undesirable social and ecological impacts (Tsing 2015). In any case, the potential of the *E3* project educational actions to boost self-organization at the neighborhood level was less precise than in the case of improving students' aspects such as agency. This result can be mainly because of the lack of evaluation at the community level (a limitation that we will discuss later). Still, it is also a shared result in previous related educational studies on energy citizenship projects showing, for instance, parents' lack of engagement (Mitchell et al. 2015). Similarly, the civic ecology practice analyzed here does not seem to work effectively in this direction. Despite that some local shops were actively involved in the initiative, this participatory scheme was not enough to engage the whole community in a mutual, intergenerational learning process and make a transformative change at broader scales beyond the students themselves. Self-organization is a community resilience attribute that depends on social connectedness (Krasny and Tidball 2010), which seems to have been downplayed when designing and implementing the educational actions in the specific case of a neighborhood with weak social networks and shared identity such as *Dreta de Eixample*. As the interviewed cooperative members pointed out, most residents were not aware of the civic ecology initiative, not actively involved in environmental stewardship, which may explain why the initiative was impacted by vandalism. The gardening of tree pits is sometimes negatively perceived by citizens and even leads to conflicts over public space use (Pellegrini and Baudry 2014). Besides, it seems that the involvement of local shops and entities in the educational action was mainly addressed to improve students' learning. In contrast, collective learning processes at the community level to support public awareness and reinforce social networks were mainly neglected, which could have deterred the initiative from creating a "new identity of membership" and further leading to community action (Aguilar 2018, 209). Environmental education literature concerned with climate change advocates for accompanying educational efforts focused on changing youth habits by public awareness campaigns to promote community engagement and empowerment (Reid 2019). This claim from environmental education is related to the emphasis that the resilience literature puts on supporting local identity and creating a sense of ownership to engage the local community in collective learning processes through reflection and interaction (Armitage, Marschke, and Plummer 2008), showing the interrelations between both fields.

Finally, as mentioned above, evaluation challenges exist in both initiatives. In the *E3* project, the cooperative surveyed the involved students and teachers about the activities conducted in and outside school. Still, it did not follow up the progress with their families and neighbors, nor did the *community gardening of tree pits* project. Implementing evaluation techniques with students' families and other community members throughout the development of the initiatives

can provide grassroots organizations working in climate resilience with valuable information to improve their educational actions to foster community transformation. However, this is not an easy task since practitioners and researchers can only approach parents indirectly. For instance, in a Canadian project partnering a university and a secondary school to encourage energy efficiency behaviors, among other objectives, only 16% of the surveys that the 112 participant students took at home were filled by their parents and returned to the school (Mitchell et al. 2015). Further, grassroots organizations implementing climate resilience initiatives and educational actions can lack the time, resources, or even the skills to design and implement an evaluation process (Seyfang and Haxeltine 2012). Some of the challenges facing the evaluation of learning processes linked to community-led climate resilience initiatives can be addressed by reinforcing alliances with researchers. Knowledge co-production can open a window of opportunity to strengthen both theoretical and practical linkages between community resilience and environmental education researchers and practitioners. In doing so, the incorporation of options for gathering formative feedback is crucial for achieving success since early data based on reflective learning can guide practitioners to identify participants' needs and improve the actions while being developed (Boyd and Osbahr 2010; Carleton-Hug and Hug 2010). Putting the evaluation emphasis into the process instead of the final outcomes of community-led climate resilience initiatives is also pertinent to avoid the instrumentalization of education and to make visible both environmentally and socially desirable and undesirable aspects of the resilience intervention, thus supporting non-normative resilience and environmental education approaches for transformation (Jickling et al. 2018; Elmqvist et al. 2019). Environmental education research on civic ecology projects can provide lessons on evaluating learning processes related to resilience attributes, such as social learning and diversity (Krasny and Tidball 2010; Smith, DuBois, and Krasny 2016). Environmental education can also benefit from adopting ethnographic approaches used in community resilience research to deeply explore transformative learning processes from the lenses of collective learning and agency (Armitage, Marschke, and Plummer 2008; Magis 2010). The analysis of learning processes that can improve stakeholders' direct management of local natural resources, which is typically addressed by the social-ecological resilience literature, can also inspire those environmental education studies that mainly focus on values, attitudes, and behaviors (Boyd and Osbahr 2010).

Conclusion

Building transformative learning processes at both individual and community levels is imperative for cities to deal with undesired and unexpected impacts of climate change. Community-based initiatives in cities can entail innovative approaches to deeply involve citizens, particularly youth, in developing and implementing urban climate resilience. Environmental education, in turn, can support youth agency and empowerment for climate action. This study contributes to shedding light on the interlinkages between environmental education and urban grassroots resilience that are related to transformative learning. We have relied on the exploratory analysis of two community-led climate resilience initiatives embedding non-formal educational actions with young students: an urban greening project based on hands-on activities in the street and an energy citizenship action based on classroom discussions and experiments and community workshops.

Our findings suggest that the pedagogical approaches behind these projects, despite their differences, mainly rely on the service-learning approach aiming to support young people's capacity to take action through voluntary work in their communities (i.e. school and neighborhood). In doing this, both initiatives promoted youth critical reflection and responsibility while reinforcing self-efficacy beliefs and agency. Such a focus on agency is crucial to facilitate transformative learning and empowerment to engage young people in climate action at both individual and collective levels. Besides cognitive, social, and structural factors shaping agency, the

resilience literature should also consider the emotional dimension highlighted in environmental education when understanding and addressing youth agency in climate action. However, our findings also show that the potential of these initiatives for promoting transformative learning processes at the community level is not clear. In this sense, we identify a lack of effective engagement approaches to actively involve community members beyond those targeting participant young people. The active and conscious involvement of the residents in these educational actions is necessary to create a community identity with both the place and the initiative that can lead to transformative action and change. In this regard, environmental education advocates for raising public awareness and reinforcing social connectedness, while the resilience literature claims to create a sense of ownership and support collective learning processes with local stakeholders. Last, our results reveal insufficient evaluation strategies when developing community-led resilience projects and related educational interventions, particularly those relying on formative approaches that emphasize the learning process more than the outcomes, which results can be used to improve practice. We argue that establishing collaborations between practitioners and researchers in both urban grassroots resilience and environmental education through knowledge co-production processes can help address these challenges. Research should further continue to advance in understanding the synergies between both fields to unravel the complexity of transformative learning processes.

Note

1. By tree pits we refer to the underground soil areas for tree roots and the surface treatment for improving water retention and pedestrian safety.

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