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School Gardens as Commons: Fostering Relational Values for Biodiversity Through Participatory Environmental Education

RESEARCH ARTICLE

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ABSTRACT

Children are particularly vulnerable to the negative effects of the current environmental, economic and health crises. As part of the European Union-funded PLANET4B project, the transformative potential of Hungarian biodiversity education on children's values, worldviews and behaviour was assessed through a critical systemic analysis, key informant interviews, and various participatory methods applied in school gardens. This paper shares some key lessons learnt from a long-lasting study conducted in one of the partner schools via two projects. In 2018, the school set up a garden together with researchers who investigated the evolution of both human-human and human-environment interactions in the frame of a participatory action research process. Throughout PLANET4B this process was continued and assessed from a long-term perspective to see if and how values, behaviour and practices can be transformed over time at the practical, personal and political level. Occasions to spend more time in the garden, and practising commoning activities, generated an emerging safe collaborative space. Here shared values could be discussed and developed, and jointly held understandings on mutual responsibility and care could be formed. Beside positive changes in individual perceptions and social norms, newly emerging teaching practices were observed, which triggered the school to further invest in nature-based solutions. Based on these results, we argue that consciously selected and carefully designed in-class and extracurricular activities can create shared values for nature, and contribute to behavioural and organisational change. Moreover, learning new ways of living and doing, such as commoning, can raise doubts about the current system and show an alternative vision for a socio-ecological future based on solidarity.

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INTRODUCTION

School gardens have already been recognised as effective tools for environmental education, offering hands-on experience that connects students with their natural environment. Existing quantitative research points out that school gardening improves children's food behaviour and educational achievements, while qualitative data shows that this immersive, experiential form of learning can enhance students' environmental and social behaviour (Blair, 2009; Williams & Dixon, 2013). As opposed to traditional classroom learning, school gardens provide space for children to translate their knowledge into practice, empowering them to understand ecological principles firsthand, while fostering collective knowledge, a sense of responsibility and mutual care for the environment (Moore et al., 2015; Skelly & Bradley, 2007). The use of outdoor green spaces also promotes physical, mental and social health by encouraging exercise and fostering engagement with the natural world (Bell & Dyment, 2008).

In addition to these individual benefits, school gardens can be a good tool for emotional and interpersonal growth. Integrating green spaces into school curricula can also affect teaching practices, empowering teachers to adopt more innovative and interactive methods (Wells & Lekies, 2012). Moreover, they provide a space for students to improve their social skills, collaborate with each other, and build a community (Bell & Dyment, 2008). Several studies have found that the common usage of outside green spaces has also strengthened social ties, made neighbourhoods more vital, and given locals a sense of community belonging (e.g., Arnberger & Eder, 2012).

This sense of community and shared stewardship ties directly to the concept of commons. As Hollender (2016) writes, through reshaping how we relate to each other and to our shared resources, the commons offers a transformative alternative to the prevailing logic of capitalist growth. The social practices of 'commoning' amplifies to a greater degree how commons are maintained and cared for (Morrow, 2019). Commoning holds the potential to transform agency, cultivate new identities, and reinforce community ties (Bergame, 2023). Based on this, school gardens can themselves be qualified as commons, where the school community jointly uses and manages the garden based on reciprocal relations (see Florea, 2025; Dimouli et al., 2024). Practising commoning activities in school gardens can thus offer alternative visions for the economy by showcasing different ways of living and doing (Moore et al., 2015). Since school gardens are usually established on public property and are tended in class by students and teachers based on collectively devised formal and informal rules, they are not identical with community gardens but a special form of urban green commons (Nettle, 2014; Göttl & Penker, 2020). By establishing school gardens, green spaces can be governed through more diverse property arrangements, contributing to urban green commons and countering the trend of privatisation (Colding & Barthel, 2013).

Despite these benefits, long-term studies on the impact of school gardens on students' values, worldviews and behaviour are limited. Existing research is usually short term, involves only small samples of students, mainly of younger age groups (i.e., elementary school), and focuses on cognitive development and attitudes instead of values and behaviour. Our paper, based on a participatory action research (PAR) study – that started in the InSPIRES project and continued within the PLANET4B project – addresses this gap by evaluating the long-lasting effects of school gardens as interventions on individual behaviour and organisational decisions, focusing on transformative change in a Hungarian secondary school (for similar recent PAR studies see Saxen et al., 2024; and Demir et al., 2023).

Transformative change is a "fundamental, system-wide reorganisation across technological, economic and social factors, including paradigms, goals and values" (IPBES, 2019, p.889), which is considered crucial to halt biodiversity loss and to ensure a future where humans can live in harmony with nature (Díaz et al, 2019). Such a system-wide reorganisation is enabled by mutual transformations at three different spheres: the practical – i.e., behaviours, strategies, actions, etc. –, the political – i.e., norms, rules, incentives, etc. –, and the personal – i.e., worldviews, values, paradigms, etc. (O'Brien, 2018). While transformations materialise through actions and interventions in the practical sphere, they will remain partial if not accompanied by changes at the political and personal sphere (Barton et al., 2024). One possibility to initiate change across the three spheres is to acknowledge and integrate the diverse values of nature into our everyday practice, political institutions, and value systems (Pascual et al., 2023).

The IPBES Values Assessment (2022) highlighted that people conceive their relationship to nature in multiple ways based on their worldviews and deeply held values. These perceived human-nature relationships strongly influence individual behaviour and institutional decisions as well as potential futures (Pascual et al., 2022). If human-nature relations are perceived as 'living from nature' – which is the predominant conceptualisation in our Western culture – nature's instrumental values are put in the forefront in our decisions, thereby simplifying nature as a resource or an asset valued for its capacity to fulfil human needs. However, people also live 'in', 'with' and 'as nature'. For instance, we can be part of a local community enjoying

and re-creating the sense of place of our landscape, we can accept the right of existence of other species, or we can feel the oneness with our ancestral tree standing in the family backyard for a hundred years. These diverse conceptualisations give rise to nature's intrinsic and relational values, i.e., nature is worth protection for itself, or for the meaningfulness of people-environment and people-people interactions (Raymond et al., 2023). To better align our decisions with sustainability, society needs to assess, acknowledge, and integrate this diversity of nature's values in decision-making. However, more profound changes are expected if societal value systems are shifted from the instrumental towards the intrinsic and relational values, and if these value shifts are reflected and deliberated in the political sphere (Horcea-Milcu et al., 2023).

Learning processes play a crucial role in weaving diverse values into everyday decisions and achieving transformative change (Van Mierlo & Beers, 2020). This paper investigates if and how school garden activities can contribute to value shifts and therefore achieve transformations in the practical, the political, and the personal sphere. We introduce a PAR project, running in a Hungarian grammar school since 2018, which aims to initiate and observe value shifts through co-creating a school garden with teachers and students. Our main objective is to assess the transformative potential of environmental education, and particularly of school gardens. In the next section, we briefly explain the contextual background and present the overall process of setting up the school garden. This is followed by a methodological overview, including critical reflections on working together with young people. In the results and discussion section we first share the observed signs of transformation in the practical, the political and the personal spheres, we then identify change agents and their role in the transformation process, before finally reflecting upon the barriers of transformative change and the limitations of this study. As a conclusion we suggest that commoning activities in school gardens can contribute to the emergence of shared values and imagining alternative visions on the ways of living.

CONTEXTUAL BACKGROUND

ENVIRONMENTAL EDUCATION IN HUNGARY

In Hungary[1], the main aim of school gardens in the 20th century was agricultural education, including horticultural training (Dani-Ördög, 2024). In recent decades, however, this focus has shifted, with a greater emphasis on sustainability education. The biodiversity of school gardens now serves more as an outdoor laboratory than a static botanical collection. The Hungarian National Curriculum (NAT) also highlights the importance of outdoor learning and folk culture – both of which school gardens are well suited to facilitate. The 2018 survey of the Hungarian Foundation for School Gardens identified more than a thousand school gardens (Halbritter et al., 2018).

Biodiversity and sustainability are well-integrated into the NAT – with elementary school teachers having the option to teach design and technology lessons in school gardens, a focus on interdisciplinary STEM[2] education until seventh grade, and the introduction of a new sustainability subject in secondary schools (Governmental Decree 5/2020). Nevertheless, several systemic challenges exist (Radó, 2021), which hinder the possible positive impacts on students' values and pro-environmental behaviour. A strong centralisation of the education system, increasing administrative burdens, changing employment conditions, and low wages contribute to a high rate of teacher resignations. These factors are limiting teacher motivation, creativity, and flexibility, thereby curtailing opportunities for experiential learning. Consequently, the transformative potential of biodiversity education is restricted to changes at the individual and organisational levels, limiting its broader impact.

THE MÓRICZ ZSIGMOND GRAMMAR SCHOOL

The study area of this research, Móricz Zsigmond Grammar School (MZSG) is located in Szentendre, an agglomeration town about 25 km from the capital. MZSG is a state-run, 4-year secondary school (the students' ages range from 14 to 19.). Students can choose from four specialisations: humanities, natural sciences (incl. biology-chemistry and information technologies sub-specialisations), foreign languages, and TanDem.[3] The TanDem specialisation uses innovative teaching methods, i.e., a more collaborative, creative and critical-democratic approach to learning. In 2025, there were 542 students in the school's 17 classes (average class size is 32 students). Most of the students came from Szentendre or the settlements around the Danube bend, and a smaller part from the nearby district of the capital. The vast majority of students were from middle or upper-middle class families, with an average of 2-3 pupils per class from families in difficult circumstances. The students were of Hungarian nationality and had Hungarian citizenship, the incidence of dual citizenship was less than 3%. The number of children with special educational needs was less than 1%. The school has a landscaped courtyard of about 500 m2 which provides space for outdoor classes, sport, recreational, and community programs, as well as the school garden.

THE SCHOOL GARDEN PROJECT

The school garden of MZSG was established in 2018 as a result of a participatory action research process, where scientists engaged teachers and 9th grade students (15-16 years old) in co-designing the garden, starting from the assessment of the strengths and weaknesses of the courtyard, to selecting the most suitable location, co-designing the architecture, picking the plant species, and then physically realising the plan through digging, planting, watering, weeding and harvesting. After the first school year when the garden was shaped, the school leadership made a joint decision on rotating responsibilities over the garden: from year to year the incoming 9th grade students enrolled in the natural science specialisation take over the tasks associated with the garden.

Over time some of the activities piloted in the first year have been continued (e.g. participatory mapping, garden festival, gardening tasks), but new activities have also emerged. The garden survived the COVID years when secondary education was ceased and home schooling was obligatory in the whole country. However, the focus has gradually shifted from plant cultivation to experimentation and leisure.

METHODOLOGICAL FRAMEWORK AND TOOLS

This study builds on a long-lasting research collaboration with MZSG, which was initiated in the frame of the InSPIRES EU Horizon 2020 project (Phase 1 between 2018–2020), and was continued within the PLANET4B Horizon Europe project (Phase 2 between 2023–24). In both projects we investigated whether and how students' relationship to nature and to each other can change through school gardening activities. Interventions were carried out by researchers and the lead teacher (the authors of this paper) together as a team, data collection and analysis was primarily done by two researchers, while the interpretation of results was again done together. Acknowledging the diversity of factors influencing biodiversity-related behaviour, we applied an intersectional lens (Thaler & Karner, 2023).

We applied an inductive analytical approach: we used qualitative, quantitative, and participatory methods (Table 1) to collect empirical data which we interpreted in an iterative and reflexive manner. Quantitative data were analysed by a researcher in MS Excel and SPSS using descriptive statistics and cross-tabulations. Visual data (e.g. photos taken by students) were interpreted by students in facilitated discussions with researchers, and the notes taken were used for further analysis. All qualitative data (incl. interview transcripts, group discussion notes, notes taken during participant observation) were coded by a researcher inductively. Codes were then aggregated into more abstract categories derived from literature (e.g., human-nature connections, nature's values), and when needed, by establishing inductive categories (e.g., change agents, emotions). The emerging coding structure was refined through several discussions within the author team. This approach helped us create an emergent theory of transformation in school gardens (Greig et al., 2007). Throughout our work we paid special attention to intersecting dimensions of social inequalities (Winker & Degele, 2011), especially age and gender, which might influence the perceptions, values and behaviour, as well as the level of engagement, of research participants.

Involving children in research entails methodological and ethical challenges, e.g., consent, confidentiality, trust, or power imbalance and domination (Einarsdottir, 2007; Punch, 2002). When dealing with these challenges a researcher can follow three main traditions: research on children (considering children as the object of scientific inquiry), research with children (considering children as the subject of, and partner in, research), and research by children (considering children as primary investigators and right-holders) (Christensen & James, 2007; Kim, 2016). When designing this study we followed the second path. We assumed that children are competent and knowledgeable members of society who can express their views on topics relevant to their everyday life and influencing their future prospects. However, we also acknowledged the persisting power imbalance between children and adults, which often silences children or urges them to please the adults they are interacting with, especially if the interaction happens in a hierarchical school setting.

Consequently, we invited our young research participants (Table 2) to take control over the research process (Alderson, 2005). We used our methodological tools flexibly and adapted not just the tools but also the discussion topics to students' needs when necessary. We always used an invitational approach: even though consent from their parents or legal guardians were a priori collected, students could refuse their participation in any of the planned research activities. Documentation included photos, videos, voice recording, and notetaking of the researchers, without recording any personal data. Data collection, storage and elimination followed the EU GDPR regulation. In Phase 1 of the research, ethical aspects of the work were regulated by the 'Terms of collaboration' signed by both MZSG and the research group. In Phase 2 of the research ethical approval was provided by Coventry University (reference number: P161616) (in accordance with their role as PLANET4B co-coordinator and ethics lead).

METHOD	APPLICATION	ANALYSIS AND RESULTS
Semi-structured interviews (Kvale, 2012)	Phase 1 (2018–2019): 5 interviews with environmental education and school gardening experts, 4 interviews with MZSG staff (headmaster, deputy headmaster, maths and biology teachers) Phase 2 (2023): 15 interviews with educational experts at the national scale, 2 interviews with MZSG staff (deputy headmaster, biology teacher)	Interviews were recorded, transcribed and coded in NVivo. Findings on the impact of the school garden are incorporated into the paper.
Participant observation (Jorgensen, 2015)	Phase 1 (2018–2019): monthly visits to the school garden throughout the school year (n = 18 over the two years). Only gardening activities were observed. A field journal was completed at every occasion by two researchers. Phase 2 (2023–2024): 1 observed school gardening event in 2023 and 2 observed school gardening events in 2024. Gardening activities and a participatory theatre play was observed. A field journal was completed at every occasion by two researchers, including reflections on the researchers' emerging feelings and opinions.	Fieldnotes were coded and analysed content-wise. Findings on human-environment and human-human interactions are incorporated into the paper, as well as researchers' personal reflections.
Participatory theatre (Jackson, 2011)	Phase 2 (2024): A participatory theatre company – the Káva Group – was invited to the school to engage students in a participatory play centred around a resource overuse conflict with biodiversity and social implications. The 9th-grade students from the Natural Science and the TanDem specialisations participated.	Researchers conducted participant observation during both plays, notes were coded and analysed content-wise. Findings on emotional involvement and group dynamics are shared in the paper.
Photovoice (Sands et al., 2009)	Phase 1: 3 volunteers in 2018 (2 female, 1 male) and 5 volunteers in 2019 (3 female, 2 male) Phase 2: 3 volunteers in 2024 (2 female, 1 male) Volunteer students used their smart phones to take pictures over 6–8 weeks to represent their relationship to nature and to each other in the garden. A group discussion followed where pictures were explained and favourite photos were selected. At the end of each school year a photo exhibition was organised.	Group discussion was recorded, transcribed and analysed content-wise together with the pictures. Selected photos and quotes from students on how they relate to the garden are shared in the paper.
Debriefing / group discussions	Phase 1: 1 group discussion and 1 debriefing in 2018 and in 2019. The group discussion in the beginning of the school year focused on expectations and was combined with a participatory mapping exercise. The debriefing sessions at the end of the school year reflected on the gardening experiences. Phase 2: 1 group discussion in 2023 and 2 debriefing sessions in 2024. The group discussion used a word café format to talk about environmental problems and potential solutions. The debriefing sessions aimed at reflecting on the participatory theatre play students enjoyed during the semester.	Notes (taken by one researcher) were analysed content-wise. Findings on emotional involvement are shared in the paper.
Survey on students' environmental attitudes (CHEAKS, Leeming et al. 1995) and nature relatedness (NR-6, Nisbet & Zelenski, 2013)	Phase 1: yearly pre- and post-activity surveys (2018–2022), using the CHEAKS scale to measure the change of environmental attitudes of students, were completed by the Natural science specialisation cohort and the Humanities specialisation cohort (control group, filled only once). Phase 2: pre- and post-activity survey in 2024, using the NR-6 scale to measure any change in students' nature-connectedness. Filled by the Natural science specialisation cohort and the TanDem specialisation cohort (control group, filled only once).	Descriptive statistics and crosstabs were analysed with SPSS and MSExcel. Since results were contradictory and showed very weak connections, survey results are not shared (see further below the limitations and challenges).

Table 1 Research and intervention methods applied in the case study.

To address methodological challenges of doing research with children and to create a safe collaborative space where different ways of expression are equally accepted, we combined a wide range of methods in both phases of the research, as explained in Table 1. In addition, several strategies were used to ensure the trustworthiness of the results, such as 1) building trust with the school community through prolonged engagement and regular presence, 2) inviting students and teachers to reflect on the research results, 3) rigorously documenting data collection and analysis, 4) researchers conducting a field diary to remain transparent about own assumptions and biases, and 5) inviting the case study advisory board members of the PLANET4B project to peer review the results.

YEAR	TOTAL NO. OF PARTICIPATING STUDENTS	GRADE	CLASS	GENDER
2018–19	68	9th (15–16 years)	Natural Sciences: 33 Humanities: 35	Female: 31 Male: 37
2019–20	65	9th (15–16 years)	Natural Sciences: 33 Humanities: 32	Female: 25 Male: 40
2022–23	33	9th (15–16 years)	Natural Sciences: 33	Female: 11 Male: 22
2023–24	61	9th (15–16 years)	Natural Sciences: 32 TanDem: 29	Female: 35 Male: 26

Table 2 Basic data of participating students.

RESULTS AND DISCUSSION

WHAT HAS CHANGED?

Changes in the *practical sphere* materialised in tangible outputs over the 7-year period. First the school's physical infrastructure started to transform: plant beds, garden tools, compost piles, watering hoses, and an outdoor classroom occupied the backyard, serving the needs of the school community. Later an insect house, bird nests and feeders were built, a significant portion of the grass was left unmowed and seeds of native wild plants were collected and sown to support the garden's non-human inhabitants and increase its biodiversity. These actions were carried out by students and teachers together, either as part of dedicated 'gardening' classes or as voluntary work, while parents could support the process by offering seedlings, gardening tools, or building materials.

While these physical outcomes were realised, relationships and patterns of collaboration also changed. Participating students could choose from different types of activities and team-up to accomplish the chosen tasks. Students' choice of activities often followed their curiosity and preferences to engage with nature in different ways, which enabled them to activate competencies less relevant in regular classroom work. This more flexible setting allowed students to make new connections, learn from each other in an informal way, and break up the cliques that existed in the classroom. Participating teachers acted rather as coordinators and facilitators – they did not control the students' contribution but engaged in the physical work as equal partners, reducing the distance in the student-teacher hierarchy. Gardening activities therefore provided ample opportunity for interaction – students and teachers could chat, have fun, or simply just relax and contemplate during class, which is unusual in the classroom.

Changes in the practical sphere were closely interlinked with transformations in the *personal sphere*. As more and more activities (e.g. learning, working, relaxing, or contemplation) got to be carried out through equal and mutual connections in the garden, the garden itself became a safe collaborative space where external expectations on individuals could be secondary to internal motivations. The open atmosphere enabled students to experience, express and discuss nature's diverse values. For instance, in Phase 1 students expressed in one of the group discussions how important a role the garden played in their lives. While instrumental values were also mentioned, they were outnumbered by references to relational (e.g.: *"During gardening, I recall plenty of good childhood memories"* [9th grade female student, 2018]) and intrinsic values (*"The garden is a sensitive being (...) If you nurture it properly, it will provide more delicious vegetables."* [9th grade male student, 2018, showing the interconnectedness of intrinsic and instrumental values]). Similarly, in Phase 2 the photovoice study elicited a plurality of instrumental, intrinsic and relational values of nature as experienced by the students in the garden (Box 1). Selected photos and the students' narrations were displayed later in the school's main hall, triggering interest and open discussions among students of all ages around the garden and nature's values in general.

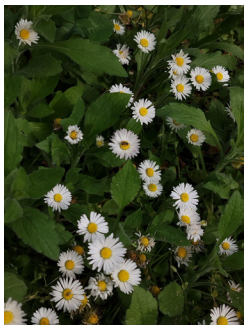
Throughout the years we observed that as the semester progressed and students spent more time in the garden, their relationship with nature became better articulated and emotions surfaced. Being in the garden was often paired with positive feelings such as joy and gratitude. On the other hand, the climate and biodiversity crisis evoked negative feelings such as frustration and fear (*"The profit overrides all other considerations by 120%"* [9th grade male, 2024]). This was especially observable during the participatory theatre play and the follow-up debriefing in Phase 2 of the research. Students reported that they felt a lack of capacities, resources, and power to develop and assert their own narrative on the nature crisis. Instead, most of the time they needed to accommodate the narrative created by adults, which puts the responsibility of solving

Box 1 Diverse values of nature in the school garden – pictures from the photovoice.

1) Instrumental values. *"People are working here. I came to the plantation, they were digging there. I took some pictures of this. There is nothing artistic behind it. Yes, I mainly tried to [document] that [work], because such nature photos... I'm not going to leave now, because I have work to do."* [9th grade male student, 2024]

2) Relational values. *"Here we put dandelions in my hair. – And do you think this is a good representation of your relationship with nature? – Well, yes, because I think it's kind of playful. And that this is how I usually play around in nature, or should I say that this way... when we go hiking, I also choose the most difficult path, and such."* [9th grade female student, 2024]

3) Intrinsic values. *"Here, among the flowers, there is a pollinating insect that is currently pollinating one of the flowers. I liked it so much because you can see that the order of nature works inside the garden, that the bugs pollinate the flowers, and everything works as it should."* [9th grade female student, 2024]



the polycrises on their shoulders (*"We don't have any other choice!"* [9th grade female]). Realising this intergenerational injustice – which to a large extent stems from the current growth-oriented economic system – and giving voice to their anger raised doubts and critical questions in the class. This is a crucial step in a transformative learning process as it leads to questioning the institutional status quo and the dominance of instrumental values, and it gives motivation to create a more pluralistic shared value system. Commoning practices in the garden provided alternative solutions to sharing work and managing resources together through reciprocal relations, and therefore could offer some positive visions as a response to their raising of system critiques (see also Moore et al. 2015).

Newly emerging social norms in the school community were the most visible sign of changes in the *political sphere*. While the garden is still coordinated by one teacher (the third author of this paper who also built an innovative master pedagogy program centred around the school garden), the fact that incoming 9th graders take over the responsibilities every year helps to engage other teachers and embed the school garden in the curriculum. The outdoor classroom and other parts of the backyard are used not just for gardening sessions but also to hold regular classes (e.g. biology, maths or languages). Changing the location of the classes also contributed to the spread of more innovative teaching approaches (e.g. interactive maths classes where small teams compete with each other in solving spatial puzzles). These new teaching approaches were also shared with other schools through exchange workshops. In addition, informal rules of commoning practices (i.e., caring for the garden together) were co-created, and new rituals were established, such as season closing bonfires or community fairs where products from the garden (e.g. lavender scented sachets) were sold to local community members. As a result, the raison d'être of the school garden is unquestionable at the school level by now.

Nevertheless, barriers for wider impacts in the political sphere also came to the surface, especially related to the rigidity and over-crowdedness of the national curriculum, the lack of financial resources, and the ageing, overburdening and burnout of teachers.[4] For as long as the results of graduation exams is the main performance indicator of secondary schools, scarce resources will be allocated to experiential learning objectives (i.e. improved awareness and adaptive capacities or more plural value approaches).

Figure 1 offers a visual overview of the observed changes and their interconnectedness, from which a narrative of change can unfold. The dark green rectangles show the three types of intervention we applied and assessed (school garden, arts-based tools such as the photovoice study or participatory theatre, and reflexive approaches, e.g. group discussions and debriefing sessions). The bright green circles indicate the first round of observable effects (changes in the practical sphere) that helped make the garden a mental and physical safe collaborative space. This safe space offered opportunities to recognise and accept the diversity of values associated with nature, to experience emotions, and to raise doubts about the broader system (light green circles, changes in the personal sphere). This then led to gradual shifts in shared values as well as in norms and behaviour at the school level (pale green circles, political sphere).

THE AGENTS OF CHANGE

The process of change cannot be fully understood without identifying the agents of change and exploring

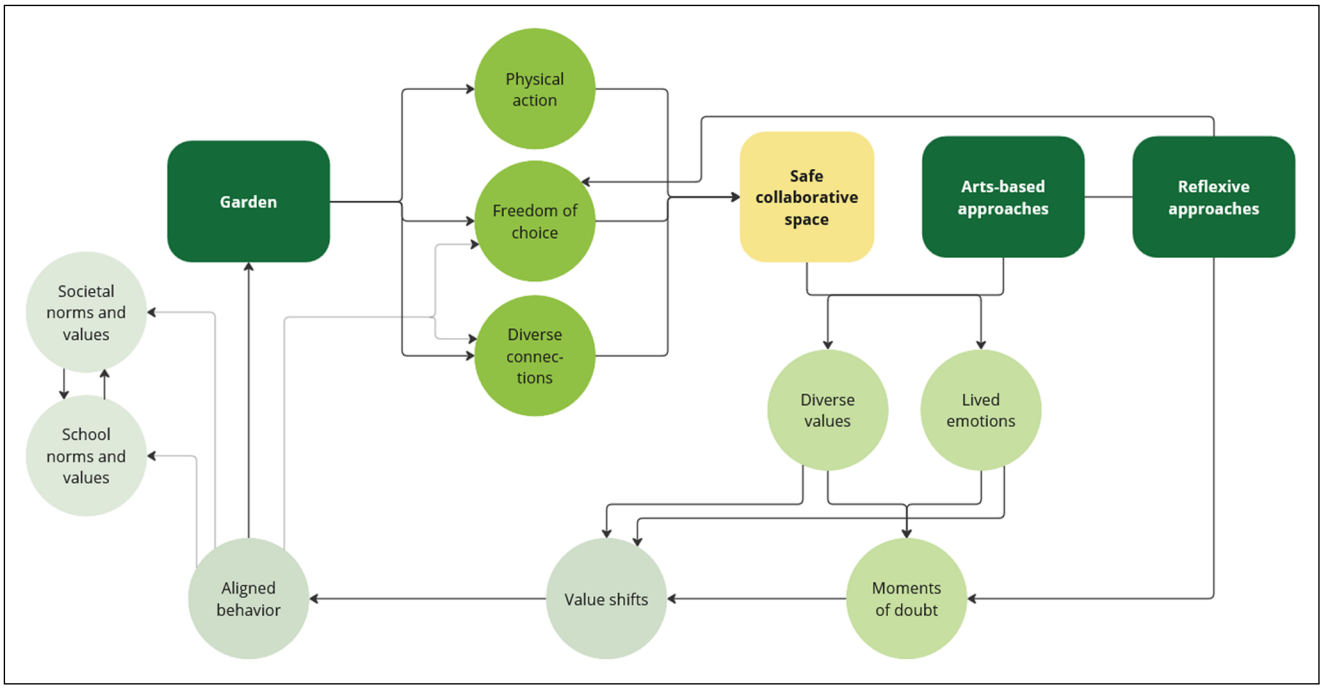


Figure 1 The narrative of transforming individual and organisational values and behaviour through a school garden.

their motivations (Gustafsson & Hysing, 2023), which was revealed by our inductive analysis as an emerging topic. Since the authors of this paper were also change agents, our lived experiences influenced the analysis, therefore we included our personal reflections (documented in field diaries) in italics to visually separate them from the analytical findings.

Teachers were the most crucial actors to initiate transformation across the three spheres. Pedagogical innovation – creating and testing lesson plans and setting up the structure of the gardening sessions for a whole year including solution-oriented outdoor modules in autumn and spring and a more problem-focused indoor module in winter – was central to achieving transformative change in the school. Gardening sessions gave space for experimentation, play, and informal learning for both the students and the teachers, letting them experience flow and recharge in the garden, and building a more equal, trust-based and joyful relationship between them. While all teachers engaged in the garden contributed to the change process, the garden coordinator (the third author of this paper) had a distinguished role by creating a shared vision which attracted support from the headmaster and the faculty, by bringing diverse actors together, and by developing new solutions on how to embed the garden into the school program.

Taking this initiator-coordinator role can be understood as a voluntary commitment fuelled by strong internal motivations.

> *In my case, this inner motivation is partly rooted in my childhood experiences: my own strong nature connectedness and the practical gardening knowledge I inherited from my parents. The other source of my personal motivation is the recognition of the discrepancy between the knowledge imparted by the school and the knowledge necessary for the future prosperity of students. Acting upon these motivations is, however, only possible if there is an open and empowering atmosphere in the school. The current changes in Hungarian educational policy exercises a growing power over schools and teachers (e.g., by limiting the choice of textbooks). Thus, the creative freedom of teachers lies in the hands of the school leadership, who can alleviate the load on teachers by fulfilling most of the requirements of the school district and the ministry by themselves.*

Students are the second most important group of agents of change. While some examples are well-known where the youth became a sustainability change agent (e.g. the Fridays for Future movement), children are still highly vulnerable and have very little power to address emerging challenges (Hickman et al., 2021). In the school garden we observed the transformation of this exposed status. Students were the main change agents regarding the transformation of the physical environment as they were digging, building, planting, weeding, and watering the garden, mediating its ecosystem services, and amending

its habitat functions. Besides, students also took part in co-learning and knowledge co-production, not necessarily in the academic sense, rather as a result of experimentation, informal exchange, and connecting. Shared experiences and common understandings emerging in the garden could integrate diverse ideas and viewpoints (e.g. around the multiple values of nature) and could complement the factual learning material of natural sciences. Moreover, working in the garden enabled them to have some instantly visible positive impact on nature, and thus strengthened their agency.

We could detect that students had different levels of openness towards the garden and nature in general. While for some of them being in nature seemed to be the most valued part of the gardening sessions, others were mostly motivated by the companionship of their friends, the fun (and sometimes challenging) activities to be accomplished, or the increased freedom of choice. Gendered differences also emerged from the qualitative analysis. Observation notes proved that boys usually chose intensive physical activities such as digging, building or watering tasks, while girls opted for planting, weeding or just observing and documenting changes in the garden. Photovoice pictures also reinforced these differences in a visual form. Furthermore, in group discussions and debriefing sessions, girls usually became more emotional and more critical towards the current economic and political system, while boys provided more rational and resigned explanations of why things happen the way they do. Our data could not reveal the roots of these differences, but because directly observed interactions with nature did not prove a strong divergence among boys and girls (e.g., we observed curiosity and caring attitudes in both groups), we assume that the differences are rather the imprints of gendered cultural expectations. Nevertheless, further research is needed to clarify these gender patterns, since not all of our advisory board members (who acted as peer reviewers to this research) could validate such interrelations.

Researchers (the first two authors of this paper) are the third type of agents in the school garden's transformative change process.

> *Throughout the research period, we have found it important to reflect on our own standpoint and intersectionality dimensions in terms of clarifying our own positionality and privileges. We discussed internally that we have a normative standpoint in this case: we believe that better integrating biodiversity into education is important, and we consciously look for options and opportunities to foster this. We also have a number of privileges compared to the students in the research, such as our age, our educational background, our greater ability to influence decision making, and the teacher-student hierarchy that comes from the rigidity of traditional education, which inadvertently elevated us to a higher social position.*
>
> *In order to soften our privileged position and to foster meaningful biodiversity education, we tried to stay flexible and responsive to the needs and feedback of both students and teachers, aiming to ensure the best possible outcome for them. This approach allowed us to facilitate a more effective and transformative learning experience. Through continuous self-reflection on our methodological choices, we recognized how our approaches influence the outcomes and shape the project. Therefore, the research process was dynamic and adaptive, often deviating from original plans to accommodate the reactions of children, better supporting their engagement and the internalisation of the impacts. An example of this is when we adapted the debriefing process after the participatory theatre play, enabling students to express their feelings and emotions. We sensed that they had been very emotionally overwhelmed by the play, so they needed this to prevent any potential harm. However, by making this decision, we were consciously losing data that we can never get back (instead of directly assessing the impacts of the theatre play, we had an additional discussion on biodiversity positive examples to ease students' negative feelings). We believe that as social science researchers, especially when working with vulnerable groups, there is a need for constant self-reflection. For the sake of our research participants, we may need to override professional criteria in certain situations.*

LIMITATIONS AND CHALLENGES

Limitations to the school garden's transformative potential are manifold. First, we observed that students visited the garden during the spring semester of 2024 much less frequently than in previous years, which probably contributed to a milder impact on students' values and behaviour. While to some extent this was due to the unusually rainy weather, the main reason was that the school garden coordinator faced an increased class load due to staffing shortages. Expert interviews reinforced that in most cases the engagement in gardening is highly dependent on the commitment and dedication of a single teacher, with no substitute to take on the responsibility.

This makes the school gardens vulnerable to organisational constraints and their longer term impacts uncertain (see also Diaz et al., 2019).

Systemic barriers pose another major challenge. Although school gardens in Hungary are part of the primary school curriculum, they are left out from the secondary school curriculum. A dedicated teacher can take students out into the school garden at the cost of their own time and energy, however, this is usually not possible as both children and teachers are significantly overburdened with other compulsory activities. In addition, a number of other systemic problems hamper the effectiveness of biodiversity education and experiential learning methods, as discussed in the section on contextual background. These factors limit the space and motivation of teachers and students alike. Consequently, the transformative potential of biodiversity education is limited to individual and organisational change, reducing its wider impact.

Finally, we must also acknowledge the limitations to observe transformative change through our research. Firstly, our study design focused on the depth, instead of the breadth, of data. Our analysis focused on a single school garden, and while we were able to robustly observe signs of transformation, these results cannot be generalised to all school gardens. Another limitation stems from the fact that this long-lasting study was carried out as part of two separate EU-funded projects, leaving us with two gap years when no data was collected. Year by year we worked together with the actual 9th grade students and did not follow-up the previous classes, therefore, while the study was long-lasting, personal impacts cannot be assessed on a longitudinal basis.

Secondly, self-selection of students was perceived as a key challenge, referring to the tendency of students who are already interested or engaged in environmental issues and activities to be more likely to actively participate in discussions and to apply for voluntary research tasks (for further discussion of participation and self-selection bias see e.g., Showalter & Mullet, 2017). Respecting the choice and the free-will of research participants ensures a safe and dominance-free dialogue, which is crucial when working with young people. However, the resulting self-selection can lead to biassed results, as the volunteering students may not be an accurate representation of the wider student population or even the class observed, skewing the results towards those with stronger human-nature connectedness and pro-environmental values.

Thirdly, in recent years, education in Hungary has been entirely saturated with politics: students and teachers regularly organise social movements against educational reforms, and articles on the subject are published in the media every day. Therefore, environmental education should not be understood as a separate entity in itself. As researchers, we empathise with the actors who are struggling in the system that have influenced our choice of topic and continue to shape our approach to this research. For this reason, we also feel the need of helping teachers in a way that does not become a burden for them, or create new tasks, but on the contrary, if possible, alleviates their difficulties.

CONCLUSION

In Hungary, the centralisation of the education system contributes to the exploitation of teachers. Their frustration often leads to the re-emergence of power imbalances between them and the students. However, in our case, MZSG appears to be an exception; here strong and supportive leadership constructs a creative atmosphere for teachers and a nurturing environment for students. A huge role in this is played by lighthouse teachers, such as the garden coordinator at MZSG – without their enthusiasm and hard work experiential learning methods such as the school garden could not survive in the long term.

Our results demonstrate that lasting, transformative change requires a democratic school community (c.f. the ideal of democratic education by Freire, 2005) and teacher(s) with strong intrinsic motivation. This leads to a certain creative freedom to pursue their own ideas and pedagogical innovations, creates a trusting, open atmosphere for experiential learning in the school garden, and puts teachers into a supportive-collaborative role (c.f., Pollin & Retzlaff-Fürst, 2021). The garden itself can be understood as a safe mediating environment where different values and perceptions can be shared, positive and negative emotions be experienced, and necessary doubts be raised. This in turn can lead to shared values about mutual care, solidarity and community building. Managing the school garden as commons gives an opportunity to turn these newly emerging shared values into practice and test reciprocal relationships as an alternative to hierarchical – and highly debated – forms of mainstream decision making.

As a further concluding thought, we suggest that researchers consider adopting an intersectional approach when assessing transformative processes for biodiversity. Students (and adults alike) connect to nature in very diverse ways, have varying levels of education, and different ways of understanding and expressing themselves. As a consequence, certain research tools (e.g. questionnaires) may work differently for some. Combining methods, such as integrating visual and narrative approaches, and tailoring the selected tools to the needs and expectations

of research participants can alleviate this issue. Still, it seems that the dimensions of intersectionality are very strongly interrelated. We acknowledge that during this research it was difficult to fully disentangle which specific factors contributed to the observed changes. Nevertheless, this research reveals certain trends regarding the transformative potential of school gardens that are worth further investigation. We encourage conducting similar studies to explore these trends on larger samples and in more diverse contexts, allowing for a deeper understanding of the various dimensions of intersectionality and exploring this topic in greater depth.

NOTES

1 This section is partly based on the expert interviews and the analysis of the Hungarian national curriculum that we conducted during the second phase of the study.

2 Acronym of Science, Technology, Engineering, and Mathematics disciplines.

3 The name of this specialisation comes from the merger of learning (TANulás in Hungarian) and democracy (DEMokrácia in Hungarian), and also refers to a tandem bicycle which needs strong collaboration to efficiently ride.

4 See e.g. https://dailynewshungary.com/photos-huge-demonstration-held-in-budapest/.

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COMPETING INTERESTS

The authors have no competing interests to declare.

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