Infusing Design Thinking into Teacher Preparation: Connecting Learners and Stakeholders Through Classroom-Based Discussions About Local Sustainability Concerns

Timothy G. Thomas

1 Introduction

The United Nation's 2030 Agenda for Sustainable Development holds 17 goals which require a global strategy to bolster the global systems upon which all life depends. These urgent goals call for universal action around economics, public health, and stewardship of natural resources. In the end, the 17 Sustainable Development Goals (SDGs) seek improved quality of life for all living things, with diminished poverty and hunger, and improvements for schools and healthcare facilities (United Nations [UN] Department of Economic and Social Affairs 2022).

In order to function as part of a solution to establish sustainable systems for long-term survival of the planet, U.S. teachers preparing to teach in the Kindergarten through twelfth grade years (K-12) must receive revolutionary training. Collegiate Education programs must prepare teachers to administer a range of alternative assessments that invite K-12 students to apply classroom knowledge to social and environmental systems in their locality.

This paper presents a framework through which U.S. educators may create lessons to engage learners with principles of sustainable design through participatory design approaches in K-12 classrooms. A design-thinking approach requires colleges to modify the traditional training that teachers receive through their Education coursework. This design-thinking approach invites learners to examine their surroundings, and as a result, to learn about local sustainability issues. Through lessons rooted in the locality, this framework can nurture a sense of agency among learners who can ultimately take action as informed stakeholders in their communities.

Design thinking is a specific collaborative practice developed in design institutes that situates human problems and human voices at the center of problem-solving.

T. G. Thomas (✉)
College of Education, James Madison University, MSC 6913/3330B Memorial Hall, Harrisonburg, VA 22807, USA
e-mail: thomastg@jmu.edu

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This method invites a divergent set of perspectives (Brown and Wyatt 2010) and seeks solutions that are informed by many voices (Chan 2018). Design thinking opens up the design process to home in on resource needs in a locality (Staszowski 2018) and recruits many disciplines to address stakeholders' concerns (IDEO 2012; Miller 2015). One illustration of a design-thinking project implemented in a collegiate classroom is the Huxtable Fellowship at Boston Architectural College (BAC). Through this project, students interviewed residents and studied climate change models to exhibit prototypes for improvements to an existing apartment building site (Peterson 2018).

Educators play a central role in the perceptions that young learners develop regarding their own connections to a place and, by extension, to the health of the people who inhabit the rest of the planet. This paper surveys the literature on participatory design to suggest ways that K-12 educators must involve learners in an inquiry process to apply classroom lessons to occurrences in their locality. In the end, this paper posits an inventory of pedagogical skills that teachers must acquire in their collegiate training. These skills will enable teachers to guide learners through participatory design projects that will display their learning about local resources in their locality.

A design project that illuminates the SDGs in a locality will seem foreign to many educators. The instructional approaches and assessments required for design projects are not within the training that K-12 teachers have customarily received. High-stakes, standardized testing has dictated the majority of teachers' work in the U.S. during the past 35 years. However, these standardized approaches have little to contribute to design thinking in classrooms. For example, teachers might deliver lessons that feature design thinking outside of typical classroom settings. Evaluation of design projects will require steps that are more complicated and multi-disciplinary (Anderson 2018) than the standardized tests to which schools have become accustomed, and an exhibition format such as the atelier (Sect. 4.1) will invite authentic demonstrations by learners to display new understandings they have acquired. Over the course of a project, educators will gauge both the content knowledge and personal growth of individual learners that evolve (Bland and Gareis 2018). Therefore, in order to develop design thinking lessons that study the SDGs in a locality, collegiate teacher training must prepare Education majors with innovative assessment skills (Harris 2021).

2 Literature Review

At the heart of sustainable solutions lies effective, inclusive design. Through participatory design projects situated in a locality to which learners have connection and with which they are familiar, educators can build on learners' attachment to a place and illuminate awareness and action connected to sustainable development. The following review explores the literature on place connection, learner agency, and participatory design.

2.1 Place Connection

Actions that meet the requirements of the SDGs will begin with the individuals who feel connected to the places in which they live, learn, work, and play. This connection influences an individual's time spent in these places (Cundill et al. 2017) and is a strong predictor of the environmental stewardship an individual will exhibit there (Gottwald and Stedman 2020; Hubbard 1993; Newman et al. 2017; Scannell and Gifford 2010a, b; Vaske and Kobrin 2001; Williams and Vaske 2003). The connection that individuals can attach to a place has been shown to affect the quality of decision-making around conservation projects in places that individuals and communities hold as significant (Clayton 2003; Newman et al. 2017; Smith et al. 2012).

Social-ecological systems (SESs) are the set of interdependent relationships that "are mediated through interactions with biophysical and non-human biological units" (Skog et al. 2018, p. 1). Skog et al. studied local food systems in Vermont and found that the following traits at work in SESs made them resilient. The systems:

- were rooted in the local community
- were built on local knowledge and identities
- held cross-sector/multi-stakeholder involvement
- prioritized feedback loops for information and reflection
- promoted collective efforts for engaging a range of stakeholder groups (p. 12).

Researchers noted that the resilience and sustainability of these systems emerged as individuals recognized a shared identity within the system and a common responsibility to care for the system.

2.2 Learner Agency

Outside of school, young learners collect multiple experiences each day, but their academic activity at school does not often include or value their experiences, particularly their experiences in Nature. Schools serve a vital function for developing student agency and a personal connection to a locality (Kumpulainen and Ouakrim-Soivio 2019). However, educators have limited opportunity during which young learners are open to lessons about sustaining the natural resources of a place (Kossack and Bogner 2012). In order for schools to prepare students who adopt practices with SDGs, learners must be presented with the knowledge, awareness, and skills to take action.

Agency is defined as a confidence in action and attitude that young people develop over time and with guidance (Kumpulainen et al. 2014). The occurrences that lead learners to experience agency include learners having opportunities to become recognized for their work, observing that their actions have some impact on the world, and taking action of their own volition (Kajamaa and Kumpulainen 2019; Kumpulainen et al. 2014; Sairanen et al. 2020).

However, as institutions, schools themselves may be ill-equipped to connect classroom lessons to learner's independent experiences in Nature. Lessons focus on the acquisition of new information and rarely draw on learners' personal experiences (Rajala et al. 2013). Even in the elementary Science classroom, learners' experiences in Nature rarely earn a mention (Carrier et al. 2013; Simms 2020; Tugurian and Carrier 2017). Science teachers find it difficult to teach lessons outdoors (Carrier et al. 2013), while learners surrender their personal connections with Nature for an academic experience about Nature comprised of notetaking and "decontextualized facts" (Tugurian and Carrier 2017, p. 149).

Indeed, learners do experience identifiable applications of rich academic content in their lives outside of school. In learners' homes, Moll et al. (1992) identified operational *funds of knowledge*—"historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (p. 133). At home children participate actively in daily life. They can help with chores, act as translators, and contribute to household income. In these settings, children are guided by their own interests and questions, a benefit not often present in classrooms. *Participatory pedagogy*, lessons which build on learners' interests, experience, and expertise from their lives outside of school, is an alternative educational approach which educators can employ to increase learners' investment in lessons.

Because increased learning about Nature does not necessarily yield increased pro-environmental behavior from learners (Kollmuss and Agyeman 2002), instruction should be intentionally timed and structured to provide lessons about the SDGs. These lessons can include models of sustainable actions as well as school-based opportunities to promote applications of classroom content into everyday experience. By replacing teacher-centered activities with structured lessons for children's reflection and independent participation, educators guide learners to develop personal agency (Kumpulainen and Ouakrim-Soivio 2019). Involving young learners with hands-on projects promotes positive conservation attitudes (Hirst 2019), and the early formation of a childhood connection to Nature continues to evolve into and through adulthood (Clayton 2003; Kals and Ittner 2003).

2.3 Participatory Design

Participatory design offers a significant fit for K-12 lessons as the natural structure of classwork can be conducive for design thinking. Lessons provide opportunities for give and take among participants and often encourage thoughtful risk-taking—both of these traits will enhance design thinking in lessons that feature the SDGs. Manzini (2014) highlights the significant roles that design and collaboration can play in catalyzing conversations about the management of local resources. He notes that designers can bring together stakeholders from diverse backgrounds to collaborate on solutions for their mutual well-being in a sustainable future. BASE Milano (2021), a creativity think-tank focused on public/private collaborations, dedicated a full day

of its Design Week 2021 to the topic of participatory design. "What is the future of the neighborhoods of our cities?" organizers asked. "Can we think of redesigning a neighborhood dimension through co-planning actions with local inhabitants and actors?" (10 September section, para. 1). Classroom lessons can pursue a similar inquiry and collaboration.

In order to educate an informed citizenry *participatory design* at school can position learners for discussion with community members around locally significant topics. Through a participatory design project, there is a conduit for exchange of ideas between experts and stakeholders, and learners will hear a variety of perspectives. Ehn (2008) outlines two essential traits of participatory design. One is the central place of democracy in participatory designs. The other trait is a valuing of users' "tacit knowledge" to inform designed solutions (p. 3).

For developing sustainability awareness and action in the locality, opportunities at school for collaborative learning (Docherty 2020; Elbakidze et al. 2015) have great potential. *Collaborative learning* is a structure that has proven useful in the field for managing conflicts around natural resource management among multiple stakeholders. Participants in this process use multiple disciplines to collaborate, exert equal effort in completing tasks, show respect for the interests and opinions of others, and empower one another toward finding equitable solutions.

Manzini has emerged as a significant champion for designers to lead social innovation. Manzini (2014) enables many to envision design as a complex yet participative activity, and to view design schools themselves as agents of sustainable change, where the next generation of designers will receive their education (Manzini 2011). Manzini employs the terms "small, open, local, and connected" (p. 8) to describe a contemporary approach to participatory design. Collaboration in design recognizes the need for networks and systems to operate in specific (small, local) contexts, yet also to function on a global (open, connected) scale (Manzini 2010). In thinking about sustainability in everyday design, designers seek new living strategies visible in stakeholder behavior to achieve sustainability (Manzini and Jegou 2003) without reliance on technology to solve dilemmas.

Notably, participatory design is not a typical component of collegiate Education programs. However, as an essential tool to address the SDGs in K-12 settings, design thinking must become an addition to the pedagogy of classrooms. Collegiate Education programs must provide training for K-12 teachers to employ exhibitions as methods to display learners' knowledge, attitudes, and skills around sustainable practices.

3 Framework

Because a participatory design project is so ambitious, an educator should not aspire to conduct every lesson or each textbook chapter with a project in mind. To begin, perhaps a teacher can select one topic for the school year which can receive the "full" participatory design treatment. The teacher can enable learners to accumulate skills

over the course of the year which will prepare them to participate in the full project, applying design-thinking principles in smaller doses in other assignments.

Also, one teacher should not feel compelled to enter the project alone. In fact, a teacher can seek another partner from the grade level, or perhaps teachers from a separate department who can lend their disciplinary skill to the design project. By their very nature, design thinking projects are multidisciplinary. Other invested educators can share their training to read essays, analyze data, or identify samples in the field.

In K-12 settings, there are a variety of entry points into a participatory design project from which teachers can select that incorporate lessons about the SDGs. Teachers and schools can select their initial gateway through which to dive into local issues:

- Content—Moll et al. (1992) encourage teachers to look to students and their families for real-world topics connected to class content. In what ways can teachers guide learners' observations to inquire about classroom topics in their everyday lives?
- Instructional delivery—Educators know that a learner's engagement with an instructional topic make all the difference in the degree to which the learner masters the topic. A participatory design framework requires learners to situate their classroom inquiry in their locality. In what ways can an educator engage learners to apply classroom content in a meaningful way?
- Exhibition—A design project culminates with a display of learners' application of the principles of the classroom content to a real-world setting. Which exhibition techniques are best suited for the information that learners are presenting and for their level of skill in displaying their new expertise? Through what methods can a teacher invite local stakeholders to participate in discussions of classroom applications?
- Evaluation—While a design project can prove engaging for educators and learners alike, once the dust settles, an educator must have a way to determine the degree to which the activity has affected the learner. In what ways can learners demonstrate their acquisition of content knowledge and their growth in awareness and attitudes about the topic?

As highlighted by this list of potential entry points, the proposed framework for design thinking does require some pedagogical duties that are outside of most current collegiate training for teachers.

This author proposes a framework for K-12 design thinking with a local sustainability focus (Table 1). The framework is comprised of five criteria, each intended to promote learner engagement. A regional focus (Criterion 1), a democratic inventory of perspectives (Criterion 2), and a public exhibition of an innovative design that addresses sustainability (Criterion 5) that small groups of learners have created collaboratively (Criterion 4) combine in an educational approach that supports sustainable decision-making (Criterion 3). With all factors in this framework, the process of community interaction around this school project must be managed by

Table 1 Framework for local K-12 design thinking with a sustainability focus

The United Nation's 2030 Agenda for Sustainable Development holds 17 Goals (SDGs) which call for a global strategy to promote the attitudes, awareness, and actions to bolster the global systems upon which all life depends (UN Department of Economic and Social Affairs 2022). This author's framework is comprised of five criteria, each criterion applied from the literature to address classroom engagement
• Criterion 1: Following a territorial ecology approach (Manzini 2013), classroom topics are situated in a local context. Presenting learners with topics set in a local and familiar context invites perspectives from experts and stakeholders attached to the locality
• Criterion 2: Classroom topics have a foundation in the experience of learners in the class, a development outlined in a discussion of participatory pedagogy (Moll et al. 1992)
• Criterion 3: Sustainability is a theme that pervades classroom topics. Skog et al. (2018) write about connections through social-ecological systems which highlight the interdependent relationships that humans share through natural resources. Acknowledging these relationships promotes opportunities for community conversations around shared resources. A discussion of local resource management rooted in both social and ecological systems presents the complexity which these decisions carry in everyday applications
• Criterion 4: The principles for collaborative learning (Elbakidze et al. 2015) govern the interaction of participants. In approaching a design thinking project, participants agree to collaborate, work as equals, and respect one another's opinions and experiences, within a process which prioritizes innovation
• Criterion 5: The learners' experience culminates with an exhibition of their application of classroom content, a performance assessment that displays their mastery of the topics and elicits their reflection on their personal growth over the course of the project (Bland and Gareis 2018; Sizer 1984)

educators in a way that prioritizes both the safety of all participants and the educative experiences of learners.

While the Framework for Local K-12 Design Thinking offers deeper learning about the SDGs for students, it also highlights the shortcomings of collegiate Education training to enable teachers to implement the project.

3.1 Criterion 1—Territorial Ecology

A teacher must be intentional about the content that is selected. A focus on the SDGs benefits from a regional setting for the project, having learners examine the layout of a larger territory to understand how the systems operating in their particular location function within a larger structure (Manzini 2013). Through examining various types of data, an educator's lesson should enable learners to understand the position of community stakeholders and to develop designs in response to the specific, authentic scenario (Melles et al. 2012). Learners' activity in the project should involve hands-on applications of classroom content.

3.2 Criterion 2—Familiar Settings and Experiences

With this design-thinking framework, educators must develop a set of "public relations" skills to connect the classroom with community stakeholders. Moll et al. (1992) highlighted the complexity of everyday life that plays out for learners and their families, a complexity that is often ignored by educators at school. The participatory pedagogy outlined by Moll et al. (1992) contained practices that more clearly connect learners to their locality. As Moll et al. noted, participatory pedagogy overcame an "insularity of classrooms" by providing real-world content inspired by learners' own experiences and opportunities for learners to form research teams about these topics (p. 139). By exploring a familiar setting through the design project, learners can bring an intimacy of the social-ecological systems (Skog et al. 2018) being examined to enhance learning of the SDGs.

3.3 Criterion 3—Sustainable Development

For K-12 settings, the re-envisioning of classroom content from the textbook to local applications is no small shift, especially in schools where it has not been attempted before. However, modified collegiate training for teachers can prepare teachers for localized design discussions about sustainability. A study of local systems will illuminate the 17 SDGs in microcosm to promote discussions about the operations of the earth's systems.

3.4 Criterion 4—Collaborative Learning

While elements of participatory design may feel foreign to a teacher's pedagogical training and practice, classrooms are an ideal setting for discussion of sustainable systems. In order for participatory design practice to be most successful, Ehn (2008) notes the necessity of an established community (such as a teacher's classroom) in which the process can occur. The established and familiar classroom setting provides comfort and safety to enable learners to produce innovative designs.

3.5 Criterion 5: Exhibiting Mastery

Within this framework, educators must prepare lessons that connect classroom content to authentic projects in the locality This authenticity also involves a culminating exhibition, having learners express to an audience what they have learned about their locality during the project. Holding an exhibition that is attended by

local stakeholders makes the classroom structure ideal to house and protect students' insights (Kollmuss and Agyeman 2002; Kumpulainen and Ouakrim-Soivio 2019).

Through the use of an exhibition format such as the atelier model (Sect. 4.1), learners will present their mastery of course content applied to the local scenario. The unique, open-response solutions from students will necessitate a skilled response from a teacher. However, to use design thinking to apply textbook content in lessons about local, sustainable natural-resource use has obstacles in U.S. Education, a teaching corps which has been steeped in over three decades of standardized testing may be hard-pressed to switch to methods of assessment.

3.6 Collecting Evidence from Learners

The collegiate pedagogical training that teachers receive can increase the array of evaluation techniques that teachers are prepared to offer. Design-thinking activities at school can provide a significant step in the development of learners who can enact the SDGs, but preparing skilled teachers to deliver lessons about sustainability will require colleges to revise the Education training that they provide.

As demonstrated by the Huxtable Fellows (Peterson 2018) in a collegiate setting, a K-12 design-thinking project will require sophisticated actions from learners to which teachers must respond. Design projects will require the following actions from learners: applying classroom content to an authentic design project, participating in community interaction to elicit stories of local stakeholders (through interviews, focus groups, and so forth), collecting and analyzing data about a local site, and so forth.

Through the culminating exhibition of the design thinking project, individual learners will display an important blend of evidence gathered over the length of the project. Ultimately, the educators will seek distinct evidence from each group's exhibition that will include information about each learner regarding the following:

- Mastery of course content: The teacher will design a method to discern to what level each learner has mastered subject-area specifics of the coursework being studied at school.
- Understanding the Sustainable Development Goals: The traits of participatory design require an operational awareness of the stakeholders' perspectives and the ecological conditions which affect the site where the project is based. The group's exhibition of a designed solution will display their understanding of the SDGs.
- A personal reflection from learners about their growth: The learners' final statement about their learning should emerge from ongoing reflective writing that they have done in which they express any new understandings that have grown out of their work on the design project.

4 Participatory Design at School

In the end, participatory pedagogy can present individual learners with an opportunity to reflect on their own agency within sustainable systems. The applications of classroom content to life outside of the classroom are plentiful; a classroom topic might illuminate growing seasons or local food sources by studying the shopping habits from learners' homes. Or during a study of natural resource management, a class might examine stormwater abatement in a nearby parking lot.

The following methods have capacity to employ the criteria (See Table 1) designated in the design thinking framework. These classroom projects will call into play the awareness and actions that are rooted in a territorial examination of authentic issues in sustainable development design. The structured classroom time spent in these collaborations will extend from learners' personal experiences and will apply topics from their classwork. Through activity in their design projects, learners will be ready to share their learning through a culminating exhibition.

4.1 The Atelier Exhibition Format

Professional designers present their ideas for public review in a variety of ways. One exhibition model with promise for K-12 settings is the *atelier*, a municipal planning format that has grown out of art and design. Traditionally, the atelier was a method for a principal master in an art studio to supervise collaborations among assistants, apprentices, and students. For a municipality, an atelier is useful to display long-range plans for regional development: it invites a review of a variety of visual and text-based data, and it requires the input of various informed voices. Through consultation with expert stakeholders, Dutch water authorities devised the Climate Atelier Approach (CAA) to shed light on the range of climate change issues, and to invite to the table the patchwork of agencies that oversee separate parts of the municipal water systems. The CAA structure provided an integrated overview of social and natural systems that is neither a top-down assigning of solutions nor a set of decisions which has emerged from the silo of a detached agency (Masselink et al. 2017).

Representatives from a variety of disciplines gather for the CAA visioning process. Together, participants review maps that illustrate the activity of natural and social systems on the landscape. Small interdisciplinary teams each design their thirty-year vision for the municipality. Each team then presents its vision and answers questions. Ultimately, the whole group discusses any insights it has gained. In the end, the goal is not to design the municipality's vision, but to employ a range of perspectives to consider possibilities that could merge into a shared vision (Masselink et al. 2017).

As illustrated by the CAA, an atelier exhibition has great promise for classrooms. This territorial modeling incorporates the collaborative role of community experts (and in learning spaces, students who are applying classroom content to

their local landscapes will function in these roles) to study local information and present a collaborative vision for future design. The whole group views each plan, then discusses together the mutual learning that they have experienced through their shared activity. Through an atelier exhibition appropriate for a particular grade-level, K-12 learners can display their content mastery and their grasp of the SDGs.

4.2 Reflective Writing by Learners

A creative learning project generates lessons that exceed the finished product itself. In classrooms, educators must provide the structure which will guide learners to reflect not only on the quality of their finished product, but on the personal growth that has resulted from the process, as well. Written reflection by each learner is indispensable to chart the degree of their growth. Reflective writing displays for both the educator and the learners themselves the changes that have occurred in learners' thinking over the course of the project.

Intentional reflective writing (similar to a diary or journal entry) must be part of the regular routine of the participatory design project. The teacher should provide writing prompts to extend class discussions, and provide distinct time dedicated to quiet reflective writing. While learners may not have a seismic shift in their learning on any single day, they may recognize trends in their record over the course of the project that will display how their learning has evolved.

As a final "tabulation" of each individual's evolution over the course of the project, the teacher should request a final statement from each learner. Learners will review their collection of journal entries then note in their statement the personal change that has occurred. For the statement, the teacher should provide a small variety of format options with appeal for a particular K-12 group—a letter to a friend or a newspaper article may be appropriate. Options for a video-recorded statement may suffice, as well.

The educator's invitation for learners to reflect on their academic experience may be the first such invitation that the learners have received to understand their connection to the natural world (Salazar et al. 2020). A clearer understanding of their connection with Nature may situate learners to readily transfer their awareness into actions that support implementing the SDGs in their local social-ecological systems.

4.3 A Participatory Design Scenario for Secondary Learners

The literature on public design thinking provides a variety of contemporary case studies which illustrate exhibition methods employed by collegiate and professional designers. The Huxtable Fellowship program provides honors students a focus on civic engagement and public interest design (Peterson 2018). A project set in East Boston sought to re-design an apartment block inhabited by forty thousand residents

and threatened by coastal flooding. Fellowship students instituted a participatory design approach by engaging residential stakeholders through a number of means. Fellowship students collected data by visiting homes and hearing the stories, cares, and concerns of residents. For the residents at the site, students presented information graphically and in multiple languages to explain climate change and potential impacts of future flooding. Students shared their findings with stakeholders through several community meetings, generated consensus, and guided the group to identify next steps in taking action.

Ultimately, the Fellowship learners re-interpreted scientific content about coastal flooding to apply it to the East Boston context. By means of their research on the ground, their exhibitions represented the voices of residents and applied their classroom content to real-world scenarios for sustainability decision-making. The East Boston project displays elements of participatory design which can be modified for learning in K-12 settings as appropriate.

For the sake of illustration, this manuscript proposes a design challenge for high school students similar to the one performed by the Huxtable Fellows (Peterson 2018). An Earth Science class in Virginia could employ this project to situate their classroom content along the Chesapeake Bay. During this project, students will be applying specifics from the state's content standards (Virginia Dept. of Education 2018) to examine a variety of data (interviews with residents, tidal patterns, projections for sea-level rise, and so forth). The lesson will illuminate information from the state standards including knowledge of engineering practices and principles of weather and climate functions. Students' exhibitions would apply this content to the specifics of the Chesapeake Bay setting. At the close of the project, teachers will assess learners' acquisition of course content and the SDG principles displayed in the exhibition, as well as personal growth that the learner can report.

5 Concluding Remarks

In order for teachers to present the SDGs to learners in a meaningful way, teacher training institutions must revise the set of skills with which they prepare teachers. This paper identifies a set pedagogical skills that collegiate Education programs must provide in order to equip teachers to elevate learners' agency to connect them to their locality through participatory design projects. The framework for design thinking described above elucidates two significant roles that classrooms can play to amplify the SDGs for learners: both affirming the experiences of learners in the natural world outside of school, and in developing awareness and practices for learners that they will use in their future decision-making as stewards of sustainably designed localities.

Design-thinking projects will raise students' learning beyond test scores. Design thinking in K-12 classrooms will promote research questions that inquire about the types of classroom engagement which finds purchase in the actions of adults who become active in systems of community sustainability. Future research may also ask about which pedagogical approaches best connect classroom learning to actions that

support the SDGs. Localities that engage with design thinking projects can chart the frequency of effective conservation actions and any change in the activity of local stakeholders in the wake of design-thinking exhibitions.

Collegiate programs for K-12 teacher preparation are indispensable links in a chain to prepare learners for sustainable actions in their communities. However, collegiate Education programs must prepare teachers who can guide learners through a framework of participatory design to a deeper understanding of the Sustainable Development Goals. The challenge is considerable to equip teachers to incorporate design thinking, a demanding format of instruction and evaluation that is "multifaceted and complex" (Anderson 2018, p. 204). For an investment in citizens who are prepared to sustain the systems that support planetary health, the pathway to fortify K-12 student design thinking will be an essential one to explore.

References

Anderson NM (2018) Evaluating student learning: engaging experience to create agents of change. In: Abendroth LM, Bell B (eds) Public interest design education guidebook: curricula, strategies, and SEED academic case studies. Routledge, pp 202–205. https://doi.org/10.4324/9781315627458

BASE Milano (2021) Public program_design week 2021. https://base.milano.it/events/public-program-designweek-2021/. Accessed 26 Mar 2022

Bland LM, Gareis CR (2018) Performance assessments: a review of definitions, quality characteristics, and outcomes associated with their use in K-12 schools. Teach Educ J 11:52–69

Brown T, Wyatt J (2010) Design thinking for social innovation. Dev Outreach 12(1):29–43. https://ojs.unbc.ca/index.php/design/article/viewFile/1272/1089

Carrier SJ, Tugurian LP, Thomson MM (2013) Elementary science indoors and out: teachers, time, and testing. Res Sci Educ 43(5):2059–2083. https://doi.org/10.1007/s11165-012-9347-5

Chan D (2018) Addressing air pollution impacts on senior citizens in Beijing, China: the international urbanization seminar. In: Abendroth LM, Bell B (eds) Public interest design education guidebook: Curricula, strategies, and SEED academic case studies. Routledge, pp 147–153. https://doi.org/10.4324/9781315627458

Clayton S (2003) Environmental identity: a conceptual and an operational definition. In: Clayton S, Opotow S (eds) Identity and the natural environment: the psychological significance of nature. The MIT Press, pp 45–65

Cundill G, Bezerra JC, De Vos A, Ntingana N (2017) Beyond benefit sharing: place attachment and the importance of access to protected areas for surrounding communities. Ecosyst Serv 28:140–148. https://doi.org/10.1016/j.ecoser.2017.03.011

Docherty M (2020) Collaborative learning: the group is greater than the sum of its parts. In: Auer M, Tsiatsos T (eds) The challenges of the digital transformation in education. ICL 2018. Advances in intelligent systems and computing, vol 916. Springer, Cham, pp 26–33. https://doi.org/10.1007/978-3-030-11932-4_3

Ehn P (2008) Participation in design things. In: Proceedings participatory design conference 2008. ACM

Elbakidze M, Dawson L, Andersson K, Axelsson R, Angelstam P, Stjernquist I, Teitelbaum S, Schlyter P, Thellbro C (2015) Is spatial planning a collaborative learning process? A case study from a rural–urban gradient in Sweden. Land Use Policy 48:270–285. https://doi.org/10.1016/j.landusepol.2015.05.001

Gottwald S, Stedman RC (2020) Preserving ones meaningful place or not? Understanding environmental stewardship behaviour in river landscapes. Landsc Urban Plan 198. https://doi.org/10.1016/j.landurbplan.2020.103778
Harris MA (2021) Growing among trees: a 12-month process evaluation of school based outdoor learning interventions. J Adventure Educ Outdoor Learn 1–12. https://doi.org/10.1080/14729679.2021.2001758
Hirst N (2019) Education for sustainability within early childhood studies: collaboration and inquiry through projects with children, Education 3-13 47(2):233–246. https://doi.org/10.1080/03004279.2018.1430843
Hubbard P (1993) The value of conservation: a critical review of behavioural research. Town Plan Rev 64(4):359
IDEO (2012) Design thinking for educators. IDEO LLC. http://designthinkingforeducators.com/
Kajamaa A, Kumpulainen K (2019) Agency in the making: analyzing students' transformative agency in a school-based makerspace. Mind Cult Act 26(3):266–281. https://doi.org/10.1080/10749039.2019.1647547
Kals E, Ittner H (2003) Children's environmental identity: indicators and behavioral impacts. In: Clayton S, Opotow S (eds) Identity and the natural environment: the psychological significance of nature. The MIT Press, pp 135–157
Kollmuss A, Agyeman J (2002) Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res 8(3):239–260. https://doi.org/10.1080/13504620220145401
Kossack A, Bogner FX (2012) How does a one-day environmental education programme support individual connectedness with nature? J Biol Educ 46(3):180–187. https://doi.org/10.1080/00219266.2011.634016
Kumpulainen K, Lipponen L, Hilppö J, Mikkola A (2014) Building on the positive in children's lives: a co-participatory study on the social construction of children's sense of agency. Early Child Dev Care 184(2):211–229. https://doi.org/10.1080/03004430.2013.778253
Kumpulainen K, Ouakrim-Soivio N (2019) "My treasure box": pedagogical documentation, digital portfolios and children's agency in Finnish early years education. In: Eckhoff A (ed) Participatory research with young children. Educating the young child (Advances in theory and research, implications for practice), vol 17. Springer, Cham, pp 105–123. https://doi.org/10.1007/978-3-030-19365-2_7
Manzini E (2010) Small, local, open, and connected: design for social innovation and sustainability. J Des Strat Chang Des 1:8–11
Manzini E (2011) Design schools as agents of (sustainable) change. In: 1st International symposium CUMULUS//DRS for design education researchers. http://www.designresearchsociety.org/docs-procs/paris11
Manzini E (2013) Resilient systems and cosmopolitan localism—the emerging scenario of the small, local, open and connected space. Econ Suffic 70:70–81
Manzini E (2014) Making things happen: social innovation and design. Des Issues 30(1):57–66. https://doi.org/10.1162/DESI_a_00248
Manzini E, Jegou F (2003) Sustainable everyday. Des Philos Pap 1(4). https://search.proquest.com/docview/993126914?accountid=11667
Masselink L, Goosen H, Grond V, Vellinga P, Leemans R (2017) Climate change in cities: an Atelier approach for municipal action. Solutions 8(1):54–65. https://thesolutionsjournal.com/article/climate-change-cities-atelier-approach-municipal-action/
Melles G, Howard Z, Thompson-Whiteside S (2012) Teaching design thinking: expanding horizons in design education. Procedia Soc Behav Sci 31:162–166. https://doi.org/10.1016/j.sbspro.2011.12.035
Miller PN (2015) Is 'design thinking' the new liberal arts? The Chronicle of Higher Education. http://chronicle.com/article/Is-Design-Thinking-the-New/228779
Moll LC, Amanti C, Neff D, Gonzalez N (1992) Funds of knowledge for teaching: using a qualitative approach to connect homes and classrooms. Theory Pract 31:132–141

Newman G, Chandler M, Clyde M, McGreavy B, Haklay M, Ballard H, Gray S, Scarpino R, Hauptfeld R, Mellor D, Gallo J (2017) Leveraging the power of place in citizen science for effective conservation decision making. Biol Conserv 208:55–64. https://doi.org/10.1016/j.biocon.2016.07.019

Peterson B (2018) Advancing resiliency: the Huxtable fellowship in civic engagement and service learning. In: Abendroth LM, Bell B (eds) Public interest design education guidebook: Curricula, strategies, and SEED academic case studies. Routledge, pp 171–178. https://doi.org/10.4324/9781315627458

Rajala A, Hilppö J, Lipponen L, Kumpulainen K (2013) Expanding the chronotopes of schooling for the promotion of students' agency. In: Erstad O, Sefton-Green J (eds) Identity, community, and learning lives in the digital age. Cambridge University Press, pp 107–125

Sairanen H, Kumpulainen K, Kajamaa A (2020) An investigation into children's agency: children's initiatives and practitioners' responses in Finnish early childhood education. Early Child Dev Care 192(1):112–123. https://doi.org/10.1080/03004430.2020.1739030

Salazar G, Kunkle K, Monroe MC (2020) Practitioner guide to assessing connection to nature. North American Association for Environmental Education. https://cdn.naaee.org/sites/default/files/assessing_connection_to_nature.7.23.20.pdf

Scannell L, Gifford R (2010a) Defining place attachment: a tripartite organizing framework. J Environ Psychol 30(1):1–10. https://doi.org/10.1016/j.jenvp.2009.09.006

Scannell L, Gifford R (2010b) The relations between natural and civic place attachment and pro-environmental behavior. J Environ Psychol 30(3):289–297. https://doi.org/10.1016/j.jenvp.2010.01.010

Simms W (2020) Bringing environmental identity research into the classroom context: examining the theoretical foundations influencing its current use in the literature. Stud Sci Educ 56(1):35–76. https://doi.org/10.1080/03057267.2020.1736379

Sizer TR (1984) Horace's compromise: the dilemma of the American high school. Houghton Mifflin

Skog KL, Eriksen SE, Brekken CA, Francis C (2018) Building resilience in social-ecological food systems in Vermont. Sustainability 10(12):1–16. https://doi.org/10.3390/su10124813

Smith JW, Siderelis C, Moore RL, Anderson DH (2012) The effects of place meanings and social capital on desired forest management outcomes: a stated preference experiment. Landsc Urban Plan 106(2):207–218. https://doi.org/10.1016/j.landurbplan.2012.03.009

Staszowski E (2018) Inclusive iteration: participation as method in design theory and practice. In: Abendroth LM, Bell B (eds) Public interest design education guidebook: curricula, strategies, and SEED academic case studies. Routledge, pp 179–181. https://doi.org/10.4324/9781315627458

Tugurian LP, Carrier SJ (2017) Children's environmental identity and the elementary science classroom. J Environ Educ 48(3):143–153. https://doi.org/10.1080/00958964.2016.1191415

United Nations Department of Economic and Social Affairs (2022). The 17 goals. https://sdgs.un.org/goals

Vaske JJ, Kobrin KC (2001) Place attachment and environmentally responsible behavior. J Environ Educ 32(4):16–21. https://doi.org/10.1080/00958960109598658

Virginia Department of Education (2018) Science standards of learning for Virginia public schools: earth science. https://www.doe.virginia.gov/testing/sol/standards_docs/science/2018/standards/stds_earth_science.docx

Williams DR, Vaske JJ (2003) The measurement of place attachment: validity and generalizability of a psychometric approach. For Sci 49(6):830–840. https://doi.org/10.1093/forestscience/49.6.830