

<https://doi.org/10.7577/formakademisk.5761>

Eva Lutnæs

Professor (PhD)

Oslo Metropolitan University (OsloMet)

evalu@oslomet.no

Locating critical design literacy

Review of lower secondary pupils' submissions for an ecovillage

ABSTRACT

This paper addresses one of the challenges presented in the call for the October 2022 symposium prior to this special issue: How would we expect design literacy (knowledge) to be demonstrated by non-designers? The study focuses on Norwegian pupils aged 15–16 years who were tasked with designing shared-living spaces for an ecovillage, aiming to encourage mixed use, inclusive social interaction, and a reduction in the carbon footprint. The study explores the level of critical design literacy demonstrated in 55 digital submissions from the pupils. The results indicate that the pupils are more proficient in expressing and discussing aspects of social sustainability than they are at addressing environmental sustainability. The paper concludes by discussing how teachers might structure projects to encourage pupils to engage more deeply in transformative design practices.

Keywords:

Digital pupil submissions, transformative design practices, shared-living spaces, socioecological sustainability.

INTRODUCTION

This paper is the fourth in a series exploring critical design literacy as a concept and practice in general education. The previous studies reviewed the scientific discourse (Lutnæs, 2019), a national curriculum (Lutnæs, 2020), and the educational design of two projects (Lutnæs, 2021). This study explores the level of critical design literacy demonstrated by pupils aged 15–16 years (non-designers) in digital submissions for an ecovillage project. Critical design literacy, which is regarded as a subset of design literacy (Lutnæs et al., 2021), emphasises the relevance of critical thinking in design processes and design education. A transition towards more sustainable ways of living depends on individuals with the courage to care and fundamentally rethink definitions of human needs and desires (United Nations Environment Program, 2011). A key premise of critical design literacy is an educational shift towards socioecological sustain-

ability, as well as the promotion of design as a practice of empathy, criticism, and responsible transformation.

Reviewing the scientific discourse on design education for the general public, we find different and rather conflicting ideas of what design literacy is and what its purposes are for society and individuals. Lerner (2018) framed design literacy as the ability to understand and make use of a canon of aesthetic forms. She advocated the positive aspects of visual–spatial learning for an individual’s cognitive growth and their advancement to a higher level of abstract thought and creation. By contrast, Pacione (2010) considered “the act of arranging how something looks” to be a stereotype of design that should be stamped out in order to convince leaders in business and government to support design thinking both in companies and as a vital part of general education (p. 11). He proposed the basic skills of inquiry, evaluation, ideation, sketching, and prototyping as design literacy for the general public, describing core design capacities as uncovering and satisfying unmet needs through iterative processes. Economic competitiveness and success in a globalised market is another goal of introducing design literacy to the general public, and design literacy is framed as the skills of creativity and innovation (Canina et al., 2013; Martin, 2009; Vande Zande, 2013; Wright et al., 2013). Economic competitiveness as the purpose of design literacy echoes Sterling’s (2001, p. 21) critique of education as mainly reinforcing unsustainable values and practices by educating to “compete and consume” rather than to “care and conserve”.

The 2013 DRS//Cumulus conference in Oslo framed design education for all as a game changer. To promote sustainability and address global challenges, professional designers are dependent on critical consumers, a design literate general public (Nielsen et al., 2015; OsloMet, 2013). Looking back at the initial arguments on why design represents an important aspect of educational development, we see some striking similarities. Design education was not introduced as a means to shape marketable innovations or beautiful forms; instead, it was intended to meet the “urgent need for the survival as well as the happiness of mankind” (Archer, 1973/2005, p. 21). Cross (1982) promoted design, along with the humanities and sciences, as a basic way of knowing. He justified design in general education through the way in which it develops abilities to tackle ill-defined real-world problems. Archer (1973/2005) and Cross (1982) framed the role of design education as empowering the individual for participation in daily life and society.

Facing human-made global challenges, I argued (Lutnæs, 2020) that the basic ethical question of how a new product or innovation makes people and the planet flourish proves just as important to integrate in the education of the young as in the education of professional designers. In a design and technology education context, Keirl (2015) put forward the role of education in helping students become skilful ethical practitioners and activists, arguing for a comprehensive and ongoing engagement with a global ethics to advance sustainability. Fleming (2013) argued for a new type of design professional who is deeply collaborative, ethically grounded, emphatically connected, and technologically empowered. In our call text for track 02 of the Learn X Design 2021 conference, we asked the following question: “How might design education empower the young generation to imagine society and everyday living differently, and to opt for sustainable design and responsible consumption?” (Lutnæs et al., 2021, p. 222). At the core of critical design literacy, we suggested “the ability to connect to real-world dilemmas with empathy, reject destructive products of human creativity and focus on problems that are worth solving” (Lutnæs et al., 2021, p. 222).

This paper takes up one of the challenges put forward by the editorial team in the call for this special issue on how we would expect design literacy to be demonstrated by non-designers (Bohemia et al., 2023, p. 3), and more specifically, how critical design literacy is demonstrated. The non-designers in this study were pupils aged 15–16 years in their final year of compulsory education in Norway. I analyse digital submissions that pupils handed in for an ecovillage project. The digital submissions consist of pictures and pupils’ critical reviews of their proposed solutions related to environmental protection and human well-being. How do pupils respond to the challenge of designing shared-living facilities that could combat social isolation and reduce the carbon footprint of housing? The research question that guides the study is as follows: What level of critical design literacy is demonstrated by lower secondary pupils in their digital submissions that present and discuss sustainable shared-living facilities for an ecovillage?

I briefly introduce the ecovillage project before explaining the methodological approaches and how the pupil submissions were analysed.

An ecovillage project as part of compulsory education in the Art and Crafts subject

Since my first year as a lower secondary teacher (school year 2015–2016), I have had the privilege of collaborating with local housing developers to design an architectural competition for Level-10 pupils (aged 15–16 years). The architectural competitions are always based on a case faced by a housing developer and designed according to the competence goals of the current national curriculum. The Art and Crafts subject, which is compulsory across Years 1 to 10, is the fifth most comprehensive subject in primary and lower secondary education. After Year 10, pupils are expected to be able to sketch and model new solutions for their local built environment that meet different needs and interests (Norwegian Directorate for Education and Training, 2020).

In 2020, a local housing developer, Nordbolig, initiated an architectural competition that challenged pupils to design shared-living spaces for a planned ecovillage. Their vision for the shared-living spaces was to enable mixed-use, inclusive social interaction and to reduce the overall carbon footprint of the 50–60 inhabitants of the ecovillage. The building site for the ecovillage is within 3.5 km of the lower secondary school and may be considered as part of pupils' local environment. The needs and interests that pupils were expected to meet through their solutions for shared-living spaces stretch across different age groups, as both family homes and senior apartments are offered (Figure 1).

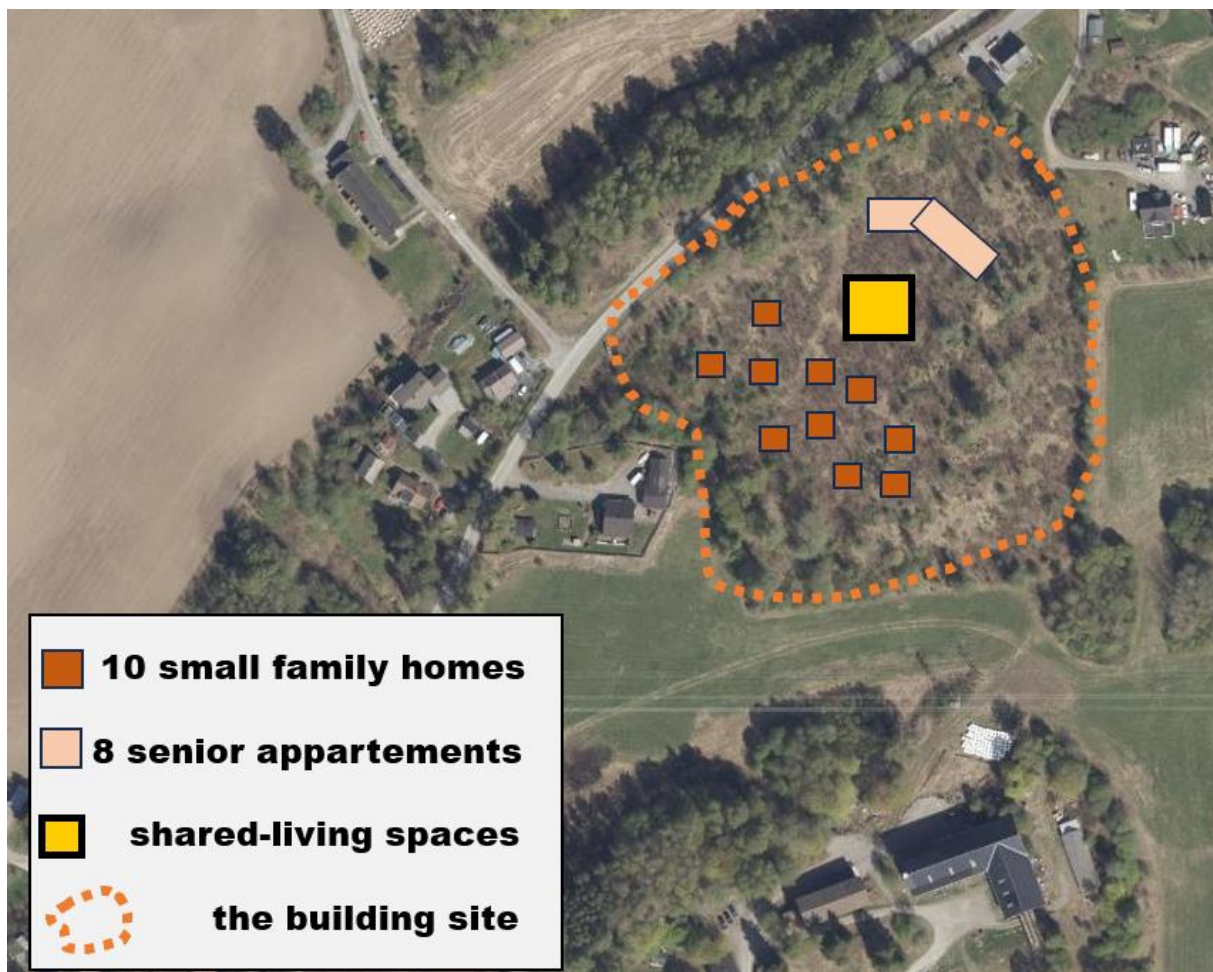


FIGURE 1. The building site for the ecovillage at Møystad farm. Photo credit: Kart1881.no (2024).

Nordbolig, the housing developer, provided a PowerPoint to familiarise pupils with the concept of an ecovillage, the site, the criteria for the competition, and a list of possible facilities that pupils could combine with their own ideas. Pupils decided whether they wanted to sign up for the competition, although all pupils were required to participate in the ecovillage project as one of three compulsory 18-hour projects for their final grade in the Art and Crafts subject. The project brief was open-ended, leaving it to pupils to decide which facilities they wanted to offer in the shared-living spaces as a response to the vision of the local housing developer. Their proposed buildings had to be within an area of 50–120 m²; in addition, they could suggest facilities for outdoor activities. Pupils made models of their buildings using Lego, Sims, cardboard, Minecraft, or SketchUp. Appendix 1 displays pupils' examples of models made for the ecovillage project, with different levels of complexity in terms of detail and form. The project submission was a digital presentation with floor plans, models, site maps, photos, and a critical review of their proposed solutions related to environmental protection and human well-being.

METHOD OF INQUIRY

The pupil submissions dataset for this study is part of a larger body of empirical data from a research project entitled *Design Literacy in Practice*, developed by PhD research fellow Ingri Strand and myself as her co-supervisor. Strand joined the ecovillage project as a co-teacher and researcher from August 2020 to May 2021. The research project explored how educational projects in lower secondary school can support socioecological responsibility regarding built environments and spatial literacy. Focusing on the latter, Strand introduced two new elements to the ecovillage project: a VR experience for all pupils at the beginning of the project and an option to continue working with VR and 3D models. Her PhD project discusses pupils' spatial literacy and the use of VR to make choices regarding the visual and functional properties of a building. Her studies (Strand & Lutnæs, 2022; Strand & Nielsen, in press) draw upon empirical data derived from semi-structured group interviews with pupils and participant observation in class. This study explores solely the pupil submissions and the level of critical design literacy that pupils demonstrated while challenged to design shared-living spaces for the ecovillage project. Strand has given her consent to the use of the pupil submissions from our shared research project as the dataset for this study.

Digital pupil submissions as the research dataset

A total of 90 pupils from a lower secondary school were invited to participate in the *Design Literacy in Practice* research project. They were given information about the purpose of the study, the possible risks, and their rights as participants before deciding on participating and signing the consent forms. Pupils under 15 years also needed consent from their parents or caregivers. Out of 90 invited pupils, 56 signed the consent forms, and 55 of these 56 pupils chose to participate in the research project through their digital presentations. The project lasted for nine weeks, involving two hours every week. Pupils had a total of 18 hours at school to work on the ecovillage project, and they were allowed to add more hours as homework. On average, pupils used 15 of the 18 hours to make floor plans and models, which left approximately three hours to work on their digital submissions at school. Pupils could choose their preferred digital software for making presentations and whether they wanted to use written words or make voice recordings to describe and evaluate their solutions. Out of 55 participants, 33 used PowerPoint presentations with notes, while 22 used either movies or PowerPoint with voice recordings.

Ethical considerations

Working both as a teacher in lower secondary education and as a professor at the university, I move between different modes of practice. My double role as a teacher and an academic allows me to explore ways of conceptualising design and critical design literacy both through texts and through what is doable within the professional learning environment and conditions of a lower secondary school. In this study, my role as a teacher serves as a “mediating component” (Dunin-Woyseth & Nilsson, 2012, p. 3) between the field of academia and the field of general education to advance our understanding of how pupils might demonstrate critical design literacy. My pupils are aware of my double role. On my side, I need to

be very specific regarding when the double role is activated. When it is, I need to conduct research in compliance with current laws, regulations, and guidelines. Trust is a common denominator for the field of research and the field of education. No information can leave the lower secondary school as empirical material unless pupils have given their informed and explicit consent to participate in research.

Analysing pupil submissions based on a definition of critical design literacy

The analysis of pupil submissions is based on a definition of critical design literacy (Lutnæs, 2019) that I developed by reviewing key texts (Christensen et al., 2018; Green, 2014; Nielsen & Brænne, 2013) for narratives regarding what it means to be a design-literate general public empowered to support critical innovation and the move towards more sustainable modes of living. In that paper (Lutnæs, 2019), I established a framework of four generative narratives on how to cultivate design literacy. Narrative A, *awareness through making*, draws on the significance, as voiced by the authors, of placing materials in the hands of pupils. Narrative B, *empower for change and citizen participation*, indicates the importance of providing pupils with a sense of agency and tools to question, rethink, and transform the world around them. Narrative C, *address the complexity of real-world problems*, promotes how pupils need to be challenged to map and navigate conflicting interests and dilemmas. Narrative D, *participate in design processes*, is the fourth narrative towards design literacy, and it is endorsed by the authors as enabling pupils to adopt the designer's tools for innovation and understanding how designers think.

I used the four narratives to analyse a curriculum text (Lutnæs, 2020) and to discuss the design of two educational projects from a teacher's perspective (Lutnæs, 2021). Why do I rely on the definition of critical design literacy rather than these four narratives for this study of pupil submissions? The four narratives provide a tool for planning and evaluating projects, educational resources, and a critical lens for reviewing visions, discourses, and educational programmes. However, I regard them as an insufficient means when it comes to a study of pupil submissions. The four narratives are tools for teachers to support pupils as they learn, whereas the submissions are the results of a learning process. The definition describes proposed learning outcome:

Being design literate in the context of critical innovation means to be aware of both the positive and negative impacts of design on people and the planet, approaching real-world problems as complex, voicing change through design processes, and judging the viability of any design ideas in terms of how they support a transition towards more sustainable ways of living. (Lutnæs, 2019, p. 1303)

Prior to the 2022 Perspectives on Design Literacy online symposium, I piloted the relevance of this definition for demonstrating aspects of critical design literacy in the dataset of pupil submissions. The definition consists of four phrases, each providing a descriptor of critical design literacy. A successful framework for coding was dependent on its correspondence with the content of the pupil submissions. For three of the four phrases in the definition, I was able to locate examples in the dataset, and the phrases were adapted to the ecovillage project with the following themes for assessing pupils' demonstration of critical design literacy:

1. Pupils use words to describe *both* the positive and negative impacts of their design or existing products and services.
2. Pupils approach real-world problems as complex by identifying the dilemmas or conflicting interests of shared living.
3. Pupils evaluate their solutions in terms of what difference they could make to encourage social interaction and reduce the carbon footprint of the ecovillage citizens.

The three themes have in common a focus on the written or spoken words that pupils make use of to discuss their proposed designed facilities for the shared-living spaces. Due to the special issue call's focus on how design literacy might be demonstrated by non-designers, I searched for signs of critical design literacy within the digital submissions. In a repetitive review of pupils' submissions, several examples were located for each critical design literacy theme, and a selected few are presented in this paper to

showcase and discuss the level of critical design literacy. Quotations and pictures from the pupil submissions are referenced with the following code: group number/pupil. The pronouns *she* and *he* are used arbitrarily for the fluency of the text.

The third phrase in the critical design literacy definition, “voicing change through design processes” (Lutnæs, 2019, p. 1303), proved unsuccessful, as the assignment for the ecovillage project did not ask pupils to document their design processes in their submissions. With a different dataset, this signifier of critical design literacy could have been a theme for coding how pupils demonstrate ability to work in a process of designing, what tools they use, and how they evaluate their ideas along the way. For this paper, I focus on the changes that pupils voice to enable inclusive social interaction and reduce the carbon footprint, as well as the facilities they suggest for the shared-living spaces. I regard pupils’ solutions as vital indicators of their level of critical design literacy: Do they suggest facilities that hold potential contributions to social sustainability, environmental sustainability, or both? This question has guided the analysis of all the facilities suggested in the dataset of 55 pupil submissions, and the results are displayed in a bubble chart model (figure 2). Each bubble represents a facility, such as a vegetable garden or a fitness room. The bubbles are placed in the pink area for their potential contribution to combatting social isolation or in the green area for their potential contribution to lowering the carbon footprint of the ecovillage citizens. Some bubbles overlap in areas, indicating their potential contributions to both. The size of each bubble is proportional to the number of pupils who suggested each facility. The bubble chart model, which gives an overview of the facilities suggested by pupils as a response to the dual challenge of socioecological responsibility provided by the local housing developer, is presented prior to the results related to the three critical design literacy themes.

The approach used is a theoretical thematic analysis (Braun & Clarke, 2006), driven by the researcher’s interest in exploring the concept of critical design literacy through an interconnected chain of papers moving from the ambitions for design education in scientific discourse (Lutnæs, 2019), the ambitions for design education in the national curriculum (Lutnæs, 2020), and the ambitions of the teacher in the design of the ecovillage project (Lutnæs, 2021) to a study of pupils’ achievements at the lower secondary education level. As explained in Lutnæs (2021), the ecovillage project was planned with neither the four narratives nor the definition of critical design literacy in mind. The definition served as a framework for the retrospective mapping of the design skills and level of critical design literacy demonstrated when pupils present and discuss their solutions for shared-living facilities in the ecovillage.

EXAMPLES OF CRITICAL DESIGN LITERACY IN PUPILS’ SUBMISSIONS

Facilities suggested by pupils for shared-living spaces

The local housing developer, *Nordbolig*, invited pupils to suggest two to four facilities for the shared-living spaces, designated to enable mixed-use, inclusive social interaction and to reduce the overall carbon footprint of the 50–60 inhabitants of the ecovillage. The submissions have an average of 4.5 suggestions, indicating that pupils were eager to come up with more ideas for shared-living spaces than requested. There is a total of 247 suggestions across the 55 digital submissions. Below is a model that provides an overview of all the facilities suggested by pupils (Figure 2).

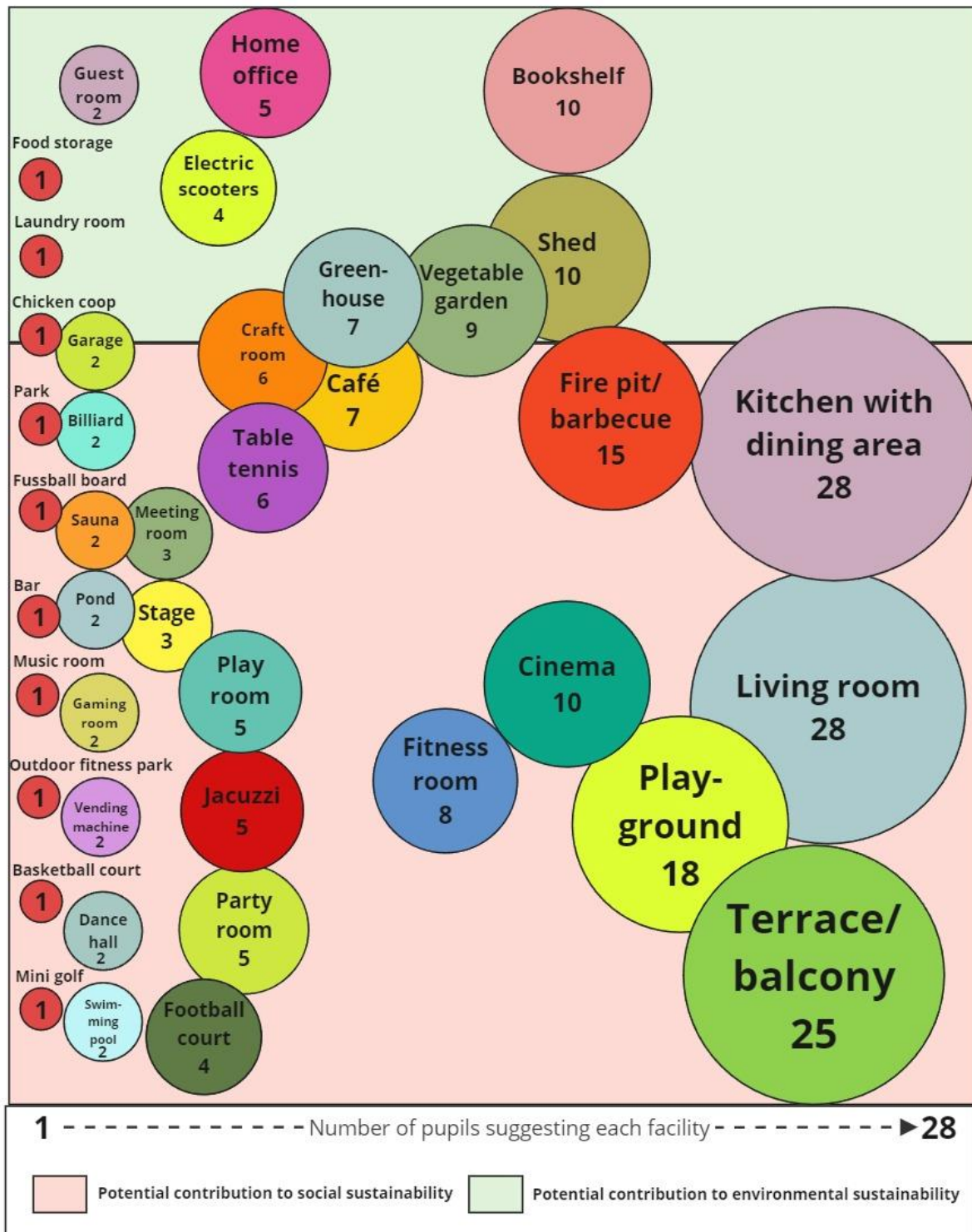


FIGURE 2. Bubble chart with all facilities suggested in the digital submissions for shared-living spaces. Bubbles in the pink area indicate potential contributions to social sustainability. Bubbles in the green area indicate potential contributions to environmental sustainability. Some bubbles overlap in areas to indicate the potential contributions to both.

The numbers in the bubble chart (Figure 2) indicate how many pupils suggested each facility, and the size of the bubbles is proportional to their numbers. The horizontal position of the bubbles relates to frequency. The far left represents the least frequent suggestions (e.g., chicken coop, suggested by one pupil), while the far right represents the most frequent suggestions (e.g., a shared living room, suggested by 28 pupils). Pupils’ design solutions were expected to reduce the total carbon emissions from

ecovillage citizens and to enable inclusive social interaction. I evaluated the suggested facilities in the context of Norwegian housing development and sorted the bubbles into either the green area (indicating potential contributions to reducing the carbon footprint) or the pink area (indicating potential contributions to human well-being, health, and combatting social isolation). The model does not indicate a hierarchy amongst the facilities in the pink or green area, and the placement and colour of each bubble on the vertical axis are arbitrary. Some of the facilities overlap the green and pink areas, potentially contributing to both. I regard the terrace/balcony as a facility for mere social interaction; thus, it is placed in the red area. The kitchen with a dining area and the fire pit / barbecue overlap, as the ecovillage citizens can host community meals and lower the carbon footprint by sharing leftover food and preparing meals based on what is harvested in their shared gardens. The pink area is by far the largest, indicating that in the dual challenge of socioecological responsibility, pupils have been more successful in advancing social sustainability than in advancing environmental sustainability. In the pink area, facilities such as a jacuzzi, pond, and basketball court provide mere leisure activities for social interaction. For most of the facilities in the pink area, it could be argued that the ecovillage inhabitants might travel less with social activities provided in their close vicinity, potentially reducing their carbon footprint. To be considered for the green area, a facility had to have inherent characteristics that could make a difference in terms of reducing the size of each family home or the amount of private equipment or facilities related to food access and the fundamental habit of eating.

A shed with shared equipment was suggested by 10 pupils and regarded as a contribution to reducing the total number of objects in the ecovillage and promoting a practice of reuse. If 18 private lawn mowers are reduced to one or two for sharing, that would significantly reduce the inhabitants' carbon footprint. Shared guestrooms and home offices have the potential to reduce the size of family homes. Some pupils' suggestions have the potential to meet both requirements. For instance, the vegetable garden could encourage co-creation and provide a low-threshold meeting place across generations, along with providing organically grown and locally sourced food. Similarly, a garage or craft room has the potential to facilitate co-learning and social interaction, as well as enabling the repair and extended use of equipment.

Theme 1. Pupils describe both the positive and negative impacts of their designs or existing products and services

Pupils were explicitly asked in their submissions to suggest specific materials and technical solutions that could minimise the negative environmental effects of the buildings. The task implied that they had to familiarise themselves with existing products or services. I made a hand-out with a list of questions and links to webpages with relevant information to get them started on this sub-task regarding the development of the ecovillage. Pupils approached the task by searching the internet for answers. Pupil 3/14 states that she does not know much about what the best choice of materials would be but considers it important that the materials are locally sourced. The pupil describes the need for insulation in Norwegian buildings and points to the positive impacts of wood fibre insulation:

Norway is a cold country, so it's important that we have ways to keep buildings insulated and protected from the winter cold. One suggestion for more environmentally friendly insulation is wood fibre. Wood fibre is a natural product, unlike mineral wool, cellular rubber, asbestos, and EPS. It also has unique properties. The material transports moisture out of the construction efficiently, can store heat, and is also sound absorbing. Together, this helps to create a good indoor climate. An example of wood fibre insulation is Hunton's wood fibre insulation, which is produced from sustainable forestry and is 100 percent recyclable. (My translation with support from DeepL Translate, quote from pupil 3/14's submission)

Pupil 3/14 uses words to describe the positive impacts on people (a good indoor climate) and on the planet (a natural product, sustainable forestry, and recyclable). A local company, Hunton, is mentioned. Comparing the pupil's text with the company's webpage (Hunton Fibre, 2024) reveals a replication of the positive features listed in their product presentation. The pupil does not show any reservations about the fact that the information on the webpage is product advertising, nor does she reflect on wood fibre

insulation's possible negative impacts on nature. While the pupil does not take a critical stance towards wood fibre as a product, she demonstrates awareness of several other existing insulation products (mineral wool, cellular rubber, asbestos). Through the word "unlike", these are presented as contrasting to the natural product of wood fibre, and they are implicitly claimed to impact nature negatively. The pupil demonstrates awareness of how insulation is a crucial product in Norwegian buildings and how it would make a difference to the environment what kind of insulation product the consumer, or in this case the housing developer Nordbolig, selects for the ecovillage.



FIGURE 3. Pupil 3/11, model made in Minecraft, combining a greenhouse, a fitness room, a roof terrace, and private party facilities.

Pupil 3/11 reflects on the positive and negative impacts of his design solutions for the shared-living spaces (Figure 3): a greenhouse, a fitness room, a roof terrace, and private party facilities. Concerning the greenhouse, the pupil lists the positive impacts as 1) locally sourced food, 2) providing a hobby for the elderly or others, 3) bringing joy of life and responsibility, and 4) ecological food. The negative impacts are listed as 1) conflict over who is responsible and 2) of little use during winter. The pupil's choice of words demonstrates awareness that the greenhouse impacts both people and the planet. For the fitness room located on the second floor of the building, the pupil's list is mainly related to people. The pupil provides a list of the social benefits of the gym: 1) of use to all citizens in the ecovillage, 2) increasing activity amongst citizens, 3) used by several people at the same time, and 4) used all year round. The one positive impact on nature is listed as 1) less requirement for transport. The ecovillage is located some kilometres from the nearest gym, and by offering a fitness room in the ecovillage, there is less need for the citizens to travel. The only negative impact listed by the pupil for the fitness room is 1) noise from the gym for those below if someone is exercising while the private party rooms are rented. The pupil's evaluation of the roof terrace is only related to its impact on people. The positive impacts are listed as 1) social, 2) an outdoor place to meet, and 3) a spot to take guests. The only negative impact is that 1) people need to walk through the gym to get to the roof terrace. The last design solution for the shared-living spaces involves private party facilities located on the first floor. The pupil lists the positive impacts as 1) use for numerous purposes (private parties, a place to meet for coffee, and meeting rooms for kids), 2) less transport required than if they had to rent private party facilities, and 3) requires smaller family homes, as people can host dinner parties there. The negative impacts are listed as 1) arguments about who might use it (e.g., on 17 May, the national day of Norway) and 2) perhaps might be used a little too occasionally.

The words that the pupil has chosen showcase awareness of the impacts on both nature and people. To legitimise the need for a private party room in the ecovillage, the pupil displays multiple situations and uses across generations. Nonetheless, there is a doubt listed amongst the negative impacts regarding whether the inhabitants will use the facilities enough. The pupil has done a thorough

job evaluating the impacts of his design solutions. For all the solutions, the list of positive impacts is longer than the list of negative impacts. This is not unexpected, given that the pupil is satisfied with his design ideas and wants the teacher to approve of them. In class, pupils were strongly encouraged to list negative impacts as well, and they were promised that the effort of doing so would only be considered favourably. Challenged to have an eye for both the positive and the negative, the words that the pupil uses are interlinked to well-known discussions of function, the reduction of materials, frequent use, and nudging people's greener everyday habits in designing built environments. An inevitable question arose as I read the pupil's lists: Do the positive impacts on people and nature justify the economic costs and negative environmental impacts of a new building? Another pupil, 3/13, states this concern explicitly as he argues for similar design ideas, consisting of a shared kitchen and greenhouse (Figure 4): "looking years ahead, the solution is environmentally friendly, but it has lots of bad impact on nature in terms of production and installation."

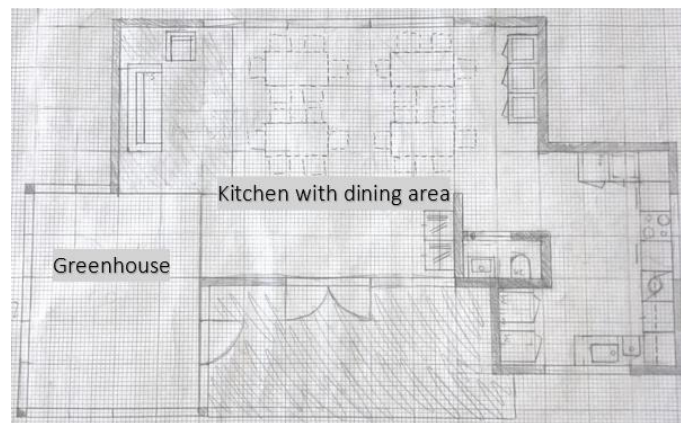


FIGURE 4. Pupil 3/13, floor plan of a building with a shared kitchen and a greenhouse.

Theme 2. Pupils approach real-world problems as complex by identifying the dilemmas or conflicting interests of shared living

The task given to pupils is a complex one. They were asked to design shared-living facilities for a specific site that would reduce the overall ecological footprint of the ecovillage inhabitants. How do pupils voice and address complexity in their submissions? In the following section, I provide some examples. A shed or garage with shared equipment is part of 12 pupils' design solutions. The proposed content differs, but a frequent idea is that the ecovillage inhabitants can share garden tools, extra chairs, sports equipment, and carpentry tools. Pupils acknowledge that problems might arise in a scheme involving sharing. Pupil 1/2 states as follows:

I think the shed will work fine, but the downside is if, for example, someone uses a tool and someone else needs it. But then they'll just have to wait. Another thing that can arise is when something is broken, who will pay? Because people who have never used the item may think it's unfair that they must pay for it. (My translation with support from DeepL Translate, quote from pupil 1/2's submission)

Pupil 1/2 voices a potential dilemma regarding how broken things could be replaced in a just manner. For the proposed conflicting interest of two people needing a tool at the same time, he urges the virtue of patience. A second pupil points to a possible conflict regarding agreement on what to acquire for the garage: "whether to spend money on a sewing machine, or whether to spend money on a pressure washer" (Pupil 3/15). Pupil 3/15 approaches the real-world problem of conflicting interests and subsequent negotiations. A third pupil voices the complexity of sharing and suggests a solution to reduce the problems:

There is an obvious problem here, and that is what if someone misplaces something? How do you keep track of who has what and when? I would put up a list where you had to write down what you took and when. (My translation with support from DeepL Translate, quote from pupil 1/4's submission)

Pupils were challenged to design facilities with a diverse offer of activities for the inhabitants. In evaluating their solutions, it is clear that they raise the issue of noise. The activities they promote have different levels of loudness, as in the combination of a music studio next to a dining room (Figure 5).



FIGURE 5. Pupil 4/13, floor plan made in SketchUp of a building with a music studio, kitchen, and dining room.

Pupil 4/13 states that the combination of a music room and shared dining room might cause disturbance for some people. Pupil 3/12 addresses the potential conflict caused by such disturbance through a clever location, suggesting that the common room for youths should be placed far from the shared kitchen and garden facilities, which he promotes as particularly attractive for the elderly inhabitants of the ecovillage.

Theme 3. Pupils evaluate their solutions in terms of what differences they could make to encourage social interaction and reduce the carbon footprint of the ecovillage citizens

Pupils were asked to explain how their design solutions contribute to improving quality of life and reducing the overall carbon footprint of the inhabitants. In this section, I review pupils' submissions in terms of how they judge the viability of their design ideas and how they identify arguments concerning the ways in which their designs support a transition towards more sustainable ways of living. One concern to battle through the design solutions was social isolation and pupils describe how their shared-living spaces might promote social interaction. Pupil 3/15 argues that "the garage also contributes to social communities, with people helping each other with things and working together. For example, if you have a moped you want to tune, you can tune it together and learn from one another". Pupil 5/21 puts forward how a multi-use hall with schemed social events enables intergenerational relationships: "Older and younger people benefit from doing things together, and good relationships might develop."

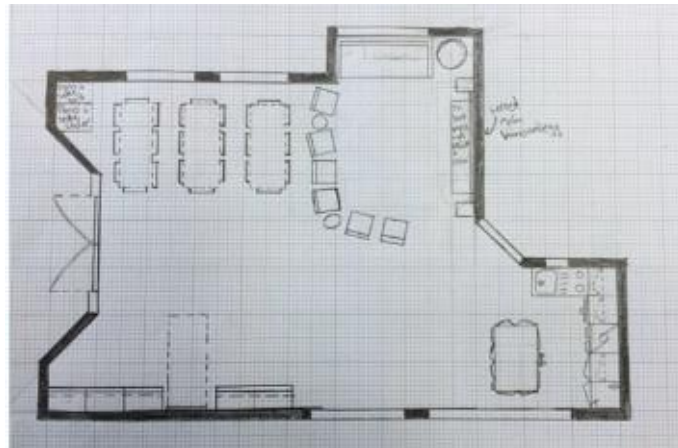


FIGURE 6. Pupil 3/14, floor plan of a multi-use room.

Pupil 3/14 also has a multi-use room as part of his design solution (Figure 6), and he states the benefits of flexibility:

The possibility of doing many different things is nice because you can do everything from watching a film and just sitting in the presence of others to hosting a big party or a workshop. For example, if you're feeling lonely one day and you don't want to sit alone, it's easy to just go and sit down with someone else in the sofa corner and chat or watch something together. (My translation with support from DeepL Translate, quote from pupil 3/14's submission)

Whereas pupil 5/21 promotes how planned social events might create new friendships, pupil 3/14 is also a spokesman for the low-threshold activity of just sitting next to another person. The shared facilities conquer loneliness by providing a place to meet others and for spontaneous interaction to occur.

Pupil 2/9 promotes his shared-living facilities as good for the environment, as he will purchase second-hand furniture:

In Norway, we dispose of 200 vans with furniture every year, most of which could be reused or repaired. Unfortunately, almost everything is thrown away, and very little is repaired and reused. That is why I think it would be smart to buy second-hand furniture. (My translation with support from DeepL Translate, quote from pupil 2/9's submission)

Running a quote check for the pupil's information reveals an even more severe picture of the amount of trash, as 200 vans of solely office furniture are disposed of not every year but every week (Rønne, 2021; Scheie, 2021; Waage, 2021). Nevertheless, the pupil's initiative regarding second-hand furniture would make a difference towards more sustainable ways of living through practices of reuse and repair. Another pupil in the same group has the idea of a swap shed with second-hand objects to aid reuse and minimise consumption: "You often buy things that you are going to use once, and now you can check in the shed booth to see if what you need is there" (Pupil 2/8). Fewer trips to the shops are also induced by a shared garden with apple trees and berries, suggested by the same pupil: "then they would not need to drive their car to buy, e.g., strawberries at the grocery store; it might reduce the emissions. Not much, but a little bit."

Pupil 4/23 describes the benefits for the environment of a shed with shared equipment:

[...] with the shed, you share things instead of everyone having their own things. This reduces the impact on the environment because fewer products are bought, and they are reused. If everyone had their own of all products, there would be a lot more to buy instead of having a few products that everyone shares. (My translation with support from DeepL Translate, quote from pupil 4/23's submission)

A common feature in how pupils judge the viability of their ideas and justify their ways of combatting climate change is that they dwell on the details of how their solutions might be environmentally friendly, but they do not question whether their ideas provide apt solutions or needed features or make a profound change towards more sustainable ways of living.

I end this display of examples from pupils' submissions by taking a closer look at pupil 1/7's spa facilities (Figures 7 and 8). The pupil takes on a salesman voice: "as indoors, there is a modern design outdoors, and I can guarantee a Mediterranean feeling." He describes the outdoor facilities as being a roof terrace with a bar, a concert venue, sun beds, a pool, and a palm made of plastic to endure the Norwegian winter. The indoor facilities are a spa with a reception area. Here are the pupil's claims in favour of the spa being environmentally friendly:

Now you may be thinking, this can't be environmentally friendly, but yes it can! I'll tell you more about that now. The spa facility was built from the remains of the other homes, and insulation for walls is also left over from the buildings. Most furniture is bought on finn.no [Norwegian webpage providing AOT private second-hand sales], and electricity comes from solar panels that are located some distance away. Water comes from the homes. After they have used the water, it runs in a tank beneath the spa facilities and is cleansed before it is used in the spa facility. Heating is via solar panels that provide power for the heat pump and so on, which means free heating. Lights also run on solar power. (My translation with support from DeepL Translate, quote from pupil 1/7's submission)

I remember asking pupil 1/7 if a spa really was a solution for reducing the overall carbon footprint of the ecovillage inhabitants. The pupil, who was extremely eager to detail his spa ideas, smiled and said that he would deal with that issue later. The above quotation reveals how the pupil dealt with my question. The idea of offering a spa is not discussed or questioned; rather, he considers more or less feasible technical solutions regarding how to build the spa.



FIGURE 7. Pupil 1/7, model made in SketchUp of spa facilities.

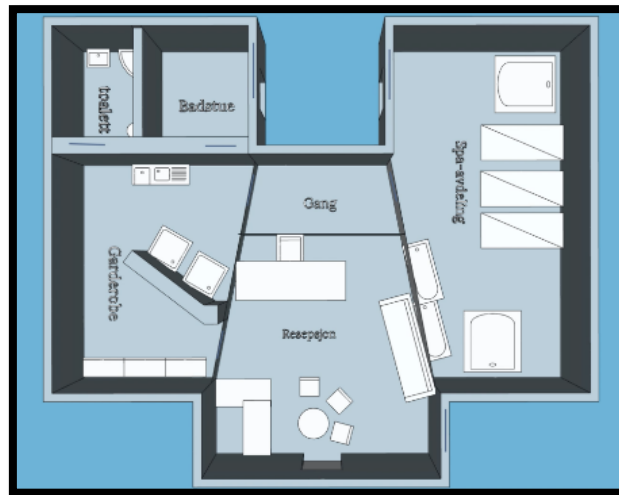


FIGURE 8. Pupil 1/7, floor plan made in SketchUp of spa facilities.

DISCUSSION

Level of critical design literacy demonstrated in pupils' submissions

In Lutnæs (2021), I explored the design of the ecovillage project from the teacher's perspective, arguing that the project holds the potential of challenging pupils to discern the possibilities of architecture for rethinking and nudging change in our modes of being in this world as societies and as individuals. The study presented in this paper makes a move from the teacher's ambitions to the learning outcomes, specifically the part of the learning outcomes that is displayed in the digital submissions that pupils handed in for the 2020–2021 ecovillage project. A dataset of 55 digital submissions was analysed to identify examples of how pupils at the level of lower secondary school demonstrate critical design literacy. How do pupils respond to the challenge of exploring and voicing more responsible alternatives? What solutions are presented to reduce the carbon footprint and encourage inclusive social interaction? How are contributions to sustainable consumption and housing discussed by pupils in the digital presentations?

A definition of critical design literacy (Lutnæs, 2019) was broken down into three themes that served as a framework for locating examples in the dataset and assessing pupils' level of critical design literacy. Related to how they discuss existing products (Theme 1), pupils are at a novice stage. Pupils can identify relevant products, but information from webpages is reproduced both uncritically (Pupil 3/14) and inaccurately (Pupil 2/9). Pupils demonstrate the ability to take a critical stance towards the facilities they suggest for the ecovillage by listing both positive and negative impacts (Theme 1). In the case of a greenhouse (Pupil 3/11), the positive impacts on nature are related to ecologically and locally sourced food, while for people, it provides a hobby that brings joy in life and responsibility. The negative impacts are conflicts related to management and the fact that the greenhouse will be of little use in the winter season. Another pupil raises the concern that it will take years of use for a greenhouse to gain a positive environmental impact (Pupil 3/13). By raising this concern, the pupil takes a critical stance, implicitly asking if the greenhouse is worth building and if the positive impacts justify the negative environmental cost of a new building in terms of the production of materials and installation at a site.

Pupils are able to identify the dilemmas and conflicting interests of shared living (Theme 2) with regard to who will pay for broken things (Pupil 1/2), agreeing on what equipment to acquire (Pupil 3/15), and issues of noise (Pupil 3/14). Reviewing their own designs in terms of how they support a transition towards more sustainable ways of living, the concern for human well-being is the dominant narrative in the submissions, compared to environmental protection (Theme 3). Figure 2 displays the vast diversity of ideas regarding what facilities the shared-living spaces could offer the ecovillage inhabitants. In their design responses, pupils are far more successful in suggesting facilities that combat social isolation than suggesting facilities that would make a noteworthy contribution to reducing the carbon footprint.

The ecovillage project asked pupils to claim a role as redirective design practitioners (Fry, 2007; Manzini, 2009) and to transform unsustainable practices of everyday living through their design responses. The ecovillage project provided a double challenge of socioecological responsibility, and the pupil submissions demonstrate a higher level of critical design literacy in expressing and discussing aspects of social sustainability. This is evident in how they embrace complexity, discuss potential conflicts, and voice positive transformations of intergenerational relationships, co-learning, a sense of belonging, and neighbours helping each other. They are able to connect to the challenge of social isolation with empathy and suggest facilities that would make a positive change. When pupils “act on other possibilities for being” (Olsen, 2019, p. 987), it becomes easier for them to deal with questions of social sustainability than questions of environmental sustainability. The social impacts are objects that are present in the life-worlds and everyday lives of these pupils with their 15–16 years of experience as social beings, while environmental impacts and questions of degrowth and climate-smart co-living communities are new to them. They deal with the local ethics of good neighbourhood, not the global ethics of planetary boundaries, with their design initiatives for advancing a sustainability that enhances the well-being of all that exists on the planet (Keirl, 2015).

The project has to some extent failed in its ambition of facilitating critical literacy in terms of pupils to fundamentally rethink human needs and desires (United Nations Environment Program, 2011) to combat climate change and loss of biodiversity. Maus (2019) described negative environmental impacts as the absent object in the studio when pupils engage with design for sustainability practices in lower secondary school. The most prominent example of environmental impact as an absent object is in the design solution of a spa with a Mediterranean feeling (Pupil 1/7). Pupil 1/7 answers the question “what would I like to make?” The pupil starts with the solution rather than with a reflective conversation with the design situation (Schön, 1984). He does not take what Christensen et al. (2018) termed a “designerly stance towards inquiry” by recognising the social and ecological problems presented by the local housing developer as wicked. The double-diamond design process of discover, define, develop, and deliver (Design Council, 2024/2003) is reduced to the simple diamond of developing and delivering. In the digital presentation, the language of sustainable architecture is adopted to legitimise the spa idea. Listing solutions readily at hand for how to make the spa environmentally friendly, the pupil approaches the design task with what Christensen et al. (2018) termed a stance of technical rationality. In judging the viability of his design ideas, he never discusses whether a spa would contribute to reducing the ecovillage inhabitants’ overall carbon footprint. Environmental concerns are an add-on to, not a premise of, the design response.

If the pupil presented his idea to the local housing developer, Nordbolig, the spa idea for the ecovillage would most likely be brusquely rejected as greenwashing (Vollero, 2022) or as prioritising human well-being at the cost of planetary health. In an educational context, the matter is more complicated. Critical design literacy is not the sole ambition of the curriculum in the Art and Crafts subject. Saying “no” to the spa idea that the pupil was so eager to implement could have made him say “no” to the other learning objectives in the ecovillage project. A researcher is relieved of pedagogical action, but a teacher is not. The teacher will have to negotiate and find solutions, as situations occur that can fuel each pupil’s desire to learn and tap into the creative potential of youth on their own terms (Hagen, 2021), even if this implies leaving behind the teacher’s ambition of pupils acting as agents of change on behalf of both people and the planet. How could I have structured the project to encourage pupils to engage more deeply in transformative design practices?

Lessons learned by the teacher

In retrospect, there are numerous skills and concepts I would have liked pupils to learn. These include the concept of greenwashing, conducting a more comparative review of products and their proposed contributions to environmental sustainability, and reviewing existing initiatives within architecture that promote themselves as making a noteworthy contribution to reducing the carbon footprint of housing. Developing critical thinking and ethical awareness is a core value across all subjects in primary and secondary education. Furthermore, sustainable development is stated to be one of three interdisciplinary topics (Norwegian Directorate for Education and Training, 2017). An opportunity for

advancing pupils' level of critical design literacy from a novice stage with respect to Theme 1 would be to reach out to other subjects, such as Social studies, Natural science, and Norwegian, for interdisciplinary collaboration. The task was one of many in the ecovillage project, and most pupils rushed through it near the deadline for submitting the digital presentations. No wonder environmental concerns were add-ons rather than a premise for their design responses. Inviting other school subjects in would allow pupils to conduct a critical review of product information by connecting knowledge from various fields of expertise and add more designated work hours for a review that was carried out as the first task of the project, not the last. My pupils were asked to generate ideas for sustainable architecture. With little or no knowledge of the field, they lacked the information needed to understand the potential for change offered by the facilities they proposed in the shared-living spaces.

This paper provides examples of how pupils at lower secondary school level demonstrate critical design literacy when explicitly prompted to do so. The in-class activities, hand-outs, and complex and open-ended task of designing shared-living spaces for an ecovillage provided educational scaffolding to support pupils in questioning, rethinking, and transforming our ways of building houses and neighbourhoods. However, pupils did not fully embrace the core of critical design literacy (Lutnæs et al., 2021). Their empathy for other people is evident from the clear win for social responsibility shown in Figure 2 and their ability to connect to the real-world dilemmas of shared living due to their 15–16 years of experience as social beings. However, their ability to reject destructive products of human creativity and focus on problems that are worth solving for the environment's sake is not as advanced. When writing this discussion, I recalled the book that I bought as a young teacher–student: *DESIGN: The problem comes first* (Bernsen, 1982). The book's core idea is that the statement of a problem holds the key to the solutions, and the first steps of a design process are paramount. As a teacher in lower secondary education, I find my pupils, being novices in design, more eager to let the solutions come first and force the problem to adapt to their solutions. In open-ended tasks with ambitious aims of design responses that could address societal and environmental challenges, there is a need for educational resources that keep pupils in the initial steps of a design process for longer.

There is no educational setting for critical design literacy unless teachers can guide pupils to connect to the situation and map out the problems. In the ecovillage project, two problems are presented: reduce the carbon footprint and combat social isolation. Both are large-scale and complex societal challenges. If I could turn back time, I would recommend to myself as a teacher the importance of taking measures that allow pupils to expand on their understanding of the problems. Using tools for design inquiry could support pupils in challenging our ways of interacting as human beings and our methods of conquering nature with buildings and infrastructure.

Prior to the development of even more educational resources, there is a more fundamental pedagogical issue that needs to be addressed. In the design of the ecovillage project, pupils' design processes are not integral to the assessment; they are only asked to document their learning outcomes by presenting and evaluating their final solutions. While developing the critical design literacy themes for coding, I had to exclude the capacity to voice change through design processes from the definition of critical design literacy. The assignment did not require pupils to document their processes. The project briefs are mediating artefacts that transform the studio into a learning space (Orr & Shreeve, 2018) with shared commitments. Excluding the design process from the expected content in the digital presentations and assessment criteria prevented pupils from investing in the crucial initial steps of the design process. A more transformative practice of designing towards environmental sustainability would involve pupils asking questions about what is truly necessary in everyday life and what we can do without. Furthermore, pupils would explore ways in which architecture might counteract environmental degradation through the activities initiated. This implies a turn from the measurable eco-efficiencies of *green* buildings towards the meaning of architecture (Cucuzzella & Gourban, 2020).

Returning to the question posed in the call for this special issue on how we would expect design literacy (knowledge) to be demonstrated by non-designers, I urge future projects not to short-circuit the design process in terms of learning outcomes and assessment evidence. Rather, the crucial documentation of critical design literacy should be of the process itself. In the education of non-designers, I suggest shifting the focus to the design process as primary evidence in assessments. It is

within the design process that pupils can demonstrate their ability to pose bold questions about our societal and individual ways of life and explore how architecture can have a positive impact on both people and the planet. However, the final product should not be neglected, as it is the tangible design solutions that hold the potential to transform unsustainable ways of living.

REFERENCES

- Archer, B. (2005). The Need for Design Education. In B. Archer, K. Baynes & P. Roberts (Eds.), *A Framework for Design and Design Education. A reader containing papers from the 1970s and 80s* (pp. 16-21). Data and Loughborough University. (Original work published 1973)
- Bernsen, J. (1982). *Design. The problem comes first*. Danish Design Council.
- Bohemia, E., Bravo, Ú., & Nielsen, L. M. (2023). Editorial I. Perspectives on Design Literacy: Building on the DLIN symposium October 2022. *FormAkademisk*, 16(5). <https://doi.org/10.7577/formakademisk.5732>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101, <https://doi.org/10.1191/1478088706qp063oa>
- Canina, M., Coccioni, E., Anselmi, L., & Palmieri, S. (2013). Designing a creativity training plan for companies. In J. B. Reitan, P. Lloyd, E. Bohemia, L. M. Nielsen, I. Digranes, & E. Lutnæs (Eds.), *Proceedings of the 2nd International Conference for Design Education Researchers: Design Learning for Tomorrow – Design Education from Kindergarten to PhD* (Vol. 4., pp. 1907–1923). ABM-media. <https://doi.org/10.21606/learnxdesign.2013.023>
- Christensen, K. S., Hjorth, M., Iversen, O. S., & Smith., R. C. (2018). Understanding design literacy in middle-school education: Assessing students' stances towards inquiry. *International Journal of Technology and Design Education*, 28, 1–22. <https://doi.org/10.1007/s10798-018-9459-y>
- Cross, N. (1982). Designerly ways of knowing. *Design Studies*, 3(4), 221–227. [https://doi.org/10.1016/0142-694X\(82\)90040-0](https://doi.org/10.1016/0142-694X(82)90040-0)
- Cucuzzella, C. & Gourban, S. (2020). *Sustainable architecture – Between Measurement and Meaning*. Vernon Press.
- Design Council. (2024). *History of the Double Diamond. A universally accepted depiction of the design process*. <https://www.designcouncil.org.uk/our-resources/the-double-diamond/history-of-the-double-diamond/> (Original work published 2003)
- Dunin-Woyseth, H., & Nilsson, F. (2012). Doctorateness in design disciplines. *FormAkademisk*, 5(2), 1–11. <https://doi.org/10.7577/formakademisk.499>
- Fleming, R. (2013). *Design Education for a Sustainable Future*. Taylor & Francis Group. <https://doi.org/10.4324/9780203584071>
- Green, M. (2014). Transformational design literacies: children as active place-makers. *Children's Geographies*, 12(2), 189-204. <https://doi.org/10.1080/14733285.2013.812305>
- Hagen, A. L. (2021). Egalitarian ideals, conflicting realities: Introducing a model for thick youth participation. In A. L. Hagen & B. Andersen (Eds.), *Ung medvirkning: Kreativitet og konflikt i planlegging* [Young participation: Creativity and conflict in planning] (pp. 277–306). Cappelen Damm Akademisk. <https://doi.org/10.23865/noasp.150.ch13>
- Hunton Fibre. (2024). *Hunton Nativo® Wood Fiber Insulation. Insulation made by natural wood fiber*. <https://huntonfiber.co.uk/>
- Keirl, S. (2015). Global Ethics, Sustainability, and Design and Technology Education. In K. Stables, & S. Keirl (Eds.) *Environment, Ethics and Cultures. International Technology Education Studies* (pp. 33-52). SensePublishers. https://doi.org/10.1007/978-94-6209-938-8_3
- Lerner, F. (2018). Visual-spatial art and design literacy as a prelude to aesthetic growth. *The International Journal of Art and Design Education*, 37(1), 65–73. <https://doi.org/10.1111/jade.12110>
- Lutnæs, E. (2019). Framing the concept design literacy for a general public. *Conference Proceedings of the Academy for Design Innovation Management*, 2(1), 1295–1305. <https://doi.org/10.33114/adim.2019.01.224>
- Lutnæs, E. (2020). Empowering Responsible Design Literacy: Identifying Narratives in a New Curriculum. *RChD: creación y pensamiento*, 5(8), 11-22. <https://doi.org/10.5354/0719-837X.2020.56120>

- Lutnæs, E. (2021). Exploring practices of critical design literacy: A comparative study of two lower secondary school design project. In E. Bohemia, L.M. Nielsen, L. Pan, N.A.G.Z. Börekçi, Y. Zhang (Eds.), *Learn X Design 2021: Engaging with challenges in design education, 24-26 September, Shandong University of Art & Design, Jinan, China*. Design Research Society. https://doi.org/10.21606/drs_lxd2021.05.138
- Lutnæs, E., Brænne, K., Homlong, S., Hofverberg, H., Maus, I.G., Fauske, L.B., Reitan, J. (2021). Track 02: Empowering critical design literacy. In E. Bohemia, L.M. Nielsen, L. Pan, N.A.G.Z. Börekçi, Y. Zhang (Eds.), *Learn X Design 2021: Engaging with challenges in design education, 24-26 September, Shandong University of Art & Design, Jinan, China*. Design Research Society. https://doi.org/10.21606/drs_lxd2021.00.313
- Martin, R. L. (2009). *The design of business: Why design thinking is the next competitive advantage*. Harvard Business Press.
- Maus, I. G. (2019). Enhancing design literacy for sustainability among youth in crafts-based design education. *Techne Series*, 26(1), 93–108. <https://journals.oslomet.no/index.php/techneA/article/view/2851>
- Ministry of Education and Research. (2019). *Curriculum for Art and Crafts (KHV01-02)*. Established as regulations. The National curriculum for the Knowledge Promotion 2020. <https://www.udir.no/lk20/khv01-02?lang=eng>
- Nielsen, L. M., & Brænne, K. (2013). Design literacy for longer lasting products. *Studies in Material Thinking*, 9(1), 1-9. <http://www.materialthinking.org/papers/125>
- Nielsen, L. M., Brænne, K., & Maus, I. G. (2015). Design Learning for Tomorrow — Design Education from Kindergarten to PhD. *FormAkademisk*, 8(1). <https://doi.org/10.7577/formakademisk.1409>
- Norwegian Directorate for Education and Training. (2017). *Core curriculum – Values and principles for lower and secondary education*. <https://www.udir.no/lk20/overordnet-del/?lang=eng>
- Olsen, C. S. (2019). Urban space and the politics of socially engaged art. *Progress in Human Geography*, 43(6), 985-1000. <https://doi.org/10.1177/0309132518807756>
- Orr, S., & Shreeve, A. (2018). *Art and Design Pedagogy in Higher Education: Knowledge, Values and Ambiguity in the Creative Curriculum*. Routledge. <https://doi.org/10.4324/9781315415130>
- OsloMet (2013). *DRS // CUMULUS Oslo 2013, 14-17 May The 2nd International Conference for Design Education Researchers*. OsloMet. <https://uni.oslomet.no/drscumulusoslo2013/>
- Pacione, C. (2010). Evolution of the mind: A case for design literacy. *Interactions*, 17(2), 6–11. <https://dl.acm.org/citation.cfm?doid=1699775.1699777>
- Rønne, S. (2021). *Kaster kontormøbler for en halv milliard i året*. [Throws away office furniture worth half a billion Norwegian kroner every year] <https://ne.no/2021/02/02/kaster-kontormobler-for-en-halv-milliard-i-aret/>
- Scheie, I. (2021). Slagsvold Vedums møbelsjokk [The furniture shock of the politician Slagsvold Vedum] (Season 1, episode 3) [Episode in a TV-program]. I K.E.M. Moen (Producer), Sløsesjokket [The Waste Shock]. NRK. <https://tv.nrk.no/serie/sloesesjokket/sesong/1/episode/3/avspiller>
- Schön, D. A. (1984). *The reflective practitioner: How professionals think in action*. Basic Books.
- Sterling, S. (2001). *Sustainable education: Re-visioning learning and change* (Vol. no. 6). Green Books for the Schumacher Society.
- Strand, I. & Lutnæs, E. (2022). Developing spatial literacy through design of built environments: Art and crafts teachers' strategies. *Design and Technology Education: An International Journal*, 27(3), 36–57 <https://openjournals.ljmu.ac.uk/DATE/article/view/1140>
- Strand, I. & Nielsen, L.M. (in process). Architecture in school practice: Possible tools for supporting spatial literacy. *International Journal of Technology and Design Education*.
- United Nations Environment Program. (2011). *Visions for change: Recommendations for effective policies on sustainable lifestyles*. <https://www.unep.org/resources/report/visions-change-recommendations-effective-policies-sustainable-lifestyles>

- Vande Zande, R. (2013). K-12 design education, creativity, and the corporate world. In J. B. Reitan, P. Lloyd, E. Bohemia, L. M. Nielsen, I. Digranes, & E. Lutnæs (Eds.), *Proceedings of the 2nd International Conference for Design Education Researchers: Design Learning for Tomorrow – Design Education from Kindergarten to PhD* (Vol. 4, pp. 2185–2195). ABM-media. <https://doi.org/10.21606/learnxdesign.2013.153>
- Vollero, A. (2022). *Greenwashing. Foundations and emerging research on corporate sustainability and deceptive communication*. Emerald Publishing Limited. <https://doi.org/10.1108/9781801179669>
- Waage, L. I. (2021). *Digitalisering og omstilling skal gi seksdobling av produksjonen* [Digitalisation and restructuring to increase production six-fold]. Stavanger Chambre of Commerce. <https://www.naeringsforeningen.no/nyheter/digitalisering-og-omstilling-skal-gi-seksdobling-av-produksjonen/>
- Wright, N., Davis, R. & Bucolo, S. (2013). The creative citizen: Understanding the value of design education programs in the knowledge economy. In J. B. Reitan, P. Lloyd, E. Bohemia, L. M. Nielsen, I. Digranes, & E. Lutnæs (Eds.), *Proceedings of the 2nd International Conference for Design Education Researchers: Design Learning for Tomorrow – Design Education from Kindergarten to PhD* (Vol. 4, pp. 2230–2248). ABM-media. <https://doi.org/10.21606/learnxdesign.2013.163>

Appendix 1. Examples of models made by pupils for the ecovillage project in a variety of materials and software.



LEGO. Models made in Lego with different levels of complexity in terms of detail and form.



MINECRAFT. Models made in Minecraft with different levels of complexity in terms of detail and form.



SKETCHUP. Models made in SketchUp with different levels of complexity in terms of detail and form.



SIMS and CARDBOARD. Models made in Sims and cardboard with different levels of complexity in terms of detail and form.