# Enhancing design literacy for sustainability among youth in crafts-based design education

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*This paper discusses the case study Case Sveip, examining enhancement of students' design literacy for sustainability in craft-based design. In 2015–2016, 2 teachers and 26 8th grade students (aged 12–13), who were organized into action group 1 (AG1) and action group 2 (AG2), participated in an action research in a Norwegian lower secondary school. Practices from design for sustainability (DfS) were introduced to the students during their craft-based designing of bentwood boxes. Thereafter, they worked with DfS principles and practices in an associated project book with introductions, tightly structured tasks and self-evaluation questions. Video recording transcripts with timekeeping and observation notes from AG1 (18 lessons, total 27 hr) and the project book responses from AG1 and AG2 (N = 24) were thematically analysed. Among the outcomes were that DfS introductions, with an average duration of approximately 6 min, were embedded in five lessons during decision-making situations about the design in sketches, work drawings and material selection. Thereafter, during 90 min of project book work, when the students assessed their finished products. The students' self-evaluations indicated that they found DfS to be understandable and useful for their design and craft practice, education and future work. However, there were indications that they were further along in their development of design literacy in DfS practices for eco-efficiency and eco-effectiveness than for product durability. This can be attributed to the distinct characteristics of these DfS practices, which held different possibilities and challenges for the students' development of design literacy for sustainability.*

Keywords: Crafts-based design, Design for sustainability (DfS), Education for sustainable development (ESD), Lower secondary education

## Introduction

Public education in design is essential for sustainable development. General education is emphasised as a key factor in sustainable development (World Commission on Environment and Development [WCED], 1987, Chapter 4. para. 3.2.; United Nations Conference on Environment and Development [UNCED], 1992, para. 36.3). The reason is that sustainability goals depend upon public participation. The United Nations' (UN) Sustainable Development Goal (SDG) 12—*ensure responsible consumption and production patterns*—seeks to reduce waste generation through prevention, reduction, recycling and reuse (UN, 2015a, para. 12.1–12.c.). This requires design competence among the public. Associated international initiatives on education are *education for sustainable development* (ESD; The United Nations Educational, Scientific and Cultural Organization [UNESCO], 2014) and *education for sustainable consumption* (ESC; United Nations Environment Programme [UNEP], 2010). ESD aims to build the necessary knowledge, skills and values to develop solutions to sustainability challenges and, moreover, aims to implement sustainable development principles and practices in all educational programmes (UNESCO, 2014, pp. 3, 9). National initiatives have also been developed, including Norway's ESD associated strategy *Utdanning for bærekraftig utvikling* (UBU; Det kongelige kunnskapsdepartement, 2012; Utdanningsdirektoratet, 2006a). Another initiative is the inclusion of sustainable development and environmental considerations in design and crafts in the curriculum for the school subject *Art and Crafts* in Norwegian primary and lower secondary school (Royal Ministry of Education, Research and Church Affairs, 1999, pp. 203–217; Utdanningsdirektoratet, 2006b, 2019).

A reading of associated research on Norwegian general education in design, crafts and sustainable development through the curriculum inquiry framework, i.e. *ideological* political intentions, *formal* curricula, *perceived* interpretations, *operationalised* education and *experiential* learning (Goodlad, Klein & Tye, 1979, pp. 58–65; Nielsen, 2009, pp. 27–31), disclosed a focus at the researches' and teachers' perceived interpretations. The research shared the perspective that youth can develop design competence for democratic participation in sustainable development and consumption by experiencing and reflecting upon the design and crafts practice (Digranes & Fauske, 2010; Illeris, 2012; Lutnæs, 2015a, 2015b, 2017; Lutnæs & Fallingen, 2017; Nielsen, 2009; Nielsen & Brænne, 2013, Nielsen & Digranes, 2007, 2012). Some made connections to international and national initiatives; Illeris (2012) coined the concept Art Education for Sustainable Development (AESD) as potential approach in ESD, while Lutnæs and Fallingen (2017) studied practices in Art and Crafts as potential approaches in UBU. Lutnæs (2015a, 2015b, 2017) studied the potential to enhance critical thinking and creativity for the development of sustainable societies in connection with ESC. Empirical studies on the perceived interpretations among art and crafts teachers concerned the possible cultivation of eco-literacy (Fallingen, 2014) and sustainable perspectives on material use (Idland, 2015). *Operationalised* educational practice was investigated in an empirical study on assessment rubrics and how these value responsible creativity in the subject Art and Crafts in lower secondary schools (Lutnæs, 2018). *Experiential* learning among lower secondary school students was investigated in two empirical studies. One concerning student perspectives on learning environmental concerns in Art and Crafts as a key issue for the operationalisation of the educational practice in DfS (Maus, 2017). Another concerning students' use of experiential learning from craft-based design practice in life cycle thinking on their product (Maus, in press). The need to develop ideology into educational practice based on associated research (Digranes & Fauske, 2010, p. 366) and for empirical studies at all levels of education (Nielsen & Digranes, 2012, pp. 21–22) have also been pointed out.

This case study, Case Sveip, contributes to the field of knowledge at the operationalised level of educational practice and the experiential level of student learning in craft-based design for sustainability (DfS) in lower secondary school. DfS principles and practices were embedded in a woodwork project to study the following research question: *What possibilities and challenges are involved in enhancing design literacy for sustainability among youth through engagement with DfS principles and practices?* To clarify the terms and concepts employed, the theoretical framework for the development of the educational practice and the data analysis will be briefly presented before the elaboration of the case and the methods are described.

## Theoretical framework

Design literacy for sustainability refers to the competence needed to understand and create DfS. The concept draws on Nielsen and Brænnes' (2013) description of design literacy as a competence for understanding and creating design in physical materials in the context of what supports sustainable environments. They emphasised the development of this competence through material creation and material knowledge in the contexts of purpose, use, production, transport, ecology and ethics. Moreover, the inclusion of ecological literacy in design (Nielsen & Brænne, 2013) in line with research by Stegall (2006), Boehnert (2015) and Lutnæs and Fallingen (2017). Other contexts discussed in recent research on design literacy are innovation (Pacione, 2010), citizenship (Nielsen & Digranes 2012, p. 18) and inquiries (Skov Christensen, Hjorth, Sejer Iversen & Blikstein, 2016). Design literacy concerns the competence acquired through design education at general and professional levels (European Design Leadership Board 2012, pp. 67–71).

DfS in product innovation (Ceschin & Gaziulusoy, 2016) is employed from the professional design field, as educational content on environmental considerations in the product design in Case Sveip. *DfS principles* that support embedding sustainability in the studio experience (Giard & Schneiderman, 2013) are used. These include product life cycle thinking (LCT) concerning raw materials extraction, manufacturing, distribution, use and disposal (Cooper, 2005; Heiskanen, 2002) and the consumptions cycle concerning prepurchasing activities, acquisition, product use and disposal (Cooper, 2005). Furthermore, the triple bottom line (TBL) aims to achieve environmental sustainability with environmental quality, social equality and economic prosperity (Elkington, 1999). *DfS practices* are also used. These include sustainable design with an intergenerational sustainable development perspective (Keitsch, 2012). In addition, there are elaborative DfS practices for eco-efficiency, with the low use of resources from cradle-to-grave (Cooper, 2005, 2010), and eco-effectiveness, with the circular use of resources from cradle-to-cradle (McDonough & Braungart, 2009, 2013). Moreover, there are DfS practices for product durability and longevity through intrinsic product qualities, including resistance to wear; reliability; upgradability; high-quality materials; and robust, carefully assembled and repairable construction. Also, there are outer aesthetic qualities, including materials that age with dignity, signs of quality and crafted details (Cooper, 2005, pp. 61–63, 2010, pp. 8–11). In addition, there are functional product qualities (Stahel, 2010) and emotionally durable products, including living objects with subject-object attachment, which is enhanced through gifts and memories (Chapman, 2009, 2010, 2015, pp. 42–47).

The theory of knowledge employed in the present study concerns students' development of holistic knowledge through engagement with educational examples in situations, incidents or items, in both objective terms of general ideas, and subjective terms of critical thinking, judgement, will and imagination (Klafki, 1959/2001, 1985/2001, pp. 101–184). Edwards' (2015) quadrant model of task sequencing to promote learning was used to develop the examples used in the present study. The model includes the following four sequences: 1) *Introduction* of key concepts and modelling of ways to engage with key concepts. 2) *Tightly structured tasks*, which demand engagement with key concepts and ways of enquiring, with formative assessments for learning through self-evaluation against criteria on the knowledge revealed and the strategies employed. 3) *More open tasks* which enable learners to apply key concepts and ways of enquiring, such as open-ended problem solving activities involving ambiguity and risk. 4) *Demonstration of grasp* of key concepts and ways of enquiring, with a summative evaluation of learning (Edwards, 2015, pp. 20–24).

## Action research in Case Sveip

The qualitative method of action research (Hiim, 2016; McNiff, 2013, 2014) is employed to construct the research data. In action research, actions are taken to improve practice. Claims about the attainment of these improvements are grounded in documentation, analysis and democratic participation (McNiff, 2013, pp. 89–130) with different contributions from the participants (Hiim, 2016).

The present case study participants included two teachers, here called June and Tor, who have subject specialisation in Art and Crafts and work in a Norwegian lower secondary school, along with 26 8th grade students (ages 12–13). The students were organised into two groups; action research group 1 (AG1) which comprised of 15 students, and action research group 2 (AG2) which comprised of 11 students. Finally, as the university researcher, I collaborated in the planning and conducted the observation, documentation and analysis of the data. The research was carried out with consent of the teachers, the students and their parents, along with the approval of the Norwegian Centre for Research Data. The participants were anonymised to protect the individual students and the names used in this article are not their real names. Consequently, their unique products were not included to avoid recognition. Unavoidably and unfortunately, anonymization deprive the participants of deserved credit (McNiff, 2013).

The case study focused on a craft-based design project to create bentwood boxes, called sveip in Norwegian, which June and Tor were developing to replace another long-running woodwork project.

Each student made a traditional bentwood box, with unique variations in his/her selections of the wood (ash or beech), size, shape, overlap, stitching (rattan or leather thread), lid and locking mechanism for the box. To complete this challenging technique, straight wood was soaked in water and bent into an oval or round shape, making a permanent change to the character of the material. The overlapping wood sections were glued and stitched, and a bottom, a lid and locking mechanisms were attached. Finally, the surfaces were treated with oil (Figure 1). The project was theoretically sampled for its challenging craft in materials, based on Nielsen and Brænnes' (2013) description of the development of design literacy through making in materials in the context of what support environmental sustainability. The teachers had experience in teaching woodwork, but not in teaching the environmental contexts. June had signed up on a list for teachers interested in participating in the research project, which involved getting help in developing DfS in their educational practice. The case was designed to embed experiential learning of DfS into the student's woodwork, thereby developing their design literacy for sustainability.

*Figure 1*. A bentwood box made by June as a model for the students' craft-based design practice.

**Data construction and analysis using the action-reflection cycle**

Action research is conducted in action-reflection cycles comprised of planning, acting, observing and reflecting on improvements in practice (McNiff, 2013, pp. 56–57, 105–118).

In the *planning phase,* June developed a model bentwood box (Figure 1), with assistance from Tor. In addition, June made instructions, learning objectives and assessment criteria. These were enclosed in a project book file in PowerPoint, together with DfS introductions, tightly structured tasks and open-ending self-evaluation questions that I developed in three stages. 1) *Defining of four overarching themes*: DfS introductions and tasks (Edwards, 2015), DfS principles and practices (Cooper, 2005, 2010; Elkington, 1999; Heiskanen, 2002; Keitsch, 2012), DfS practices for eco-efficiency and eco-effectiveness (Cooper, 2005, 2010; McDonough and Braungart, 2009, 2013) and DfS practices for product durability (Chapman, 2009, 2010, 2015; Cooper, 2005, 2010; Stahel, 2010). 2) *Development of seven interpretive themes* for the introductions and tightly structured tasks with the following project book headings: Design and sustainability; Functional design; Traditional design, unique details; Accuracy in craft; Materials with sustainable life cycle; Construction, repair and maintenance; and Value, price, wages and material costs. 3) *Development of four self-evaluation questions* on the students' experiential learning with the following project book headings: Difficulties, Usefulness of knowledge on sustainability and design, Problem solving for sustainable design and Crafts. The project book texts were in Norwegian, encouraging the students' responses in their own formulation. Technical terms, researchers' names and sources were omitted. During the project book development, June and I maintained an open dialogue; drafts were assessed by June and adjusted accordingly multiple times. In addition, two students assessed the project book before the students project book work in the last lesson.

In the *acting* phase, from August 2015 until January 2016, AG1 and AG2 each had 18 lessons of 90 minutes (total 27 hr) for a combined total of 36 lessons (54 hr). June taught 27 of these lessons, and Tor taught six lessons as a substitute teacher. Two other substitute teachers taught one and two lessons, respectively. In lessons 1–17, which focused on craft-based designing of the bentwood box in the school studio, DfS was introduced by June and Tor when they found it expedient. In lesson 18, June and the students worked on the DfS introductions and tasks in the project book in a computer room. At no point did I act as a teacher.

In the *observation* phase, the data was documented in three ways: 1) I made video recording transcripts and timekeeping and observation notes of the DfS engagement sequences in AG1 (18 lessons, 27 hr). This data sample had little interference by non-participants, moreover represents the similar project progression in AG1 and AG2 that I documented in observation notes and video recordings from all the lessons in both groups. 2) The students recorded their task and self-evaluation responses in their project books (N = 24). Some responses referred to several themes, while four project books lacked some responses. Consequently, the data do not always sum up to 24. Two of the 26 students did not hand in their project books. 3) I made logs and memos from the meetings with the teachers.

The *reflection* phase involved quantitative and qualitative analysis of the data (McNiff, 2013, pp. 111–112). Thematic coding, which was inspired by interview analysis (King & Horrocks, 2010, pp. 142–174), was conducted in three stages: 1) *Descriptive coding* by anonymizing the data into coded, analytical units. 2) *Interpretive coding* of the data according to the seven interpretive themes: Design and sustainability; Functional design; Traditional design, unique details; Accuracy in craft; Materials with sustainable life cycle; Construction, repair and maintenance; and Value, price, wages and material costs. 3) *Organizing the data in the four overarching themes*: DfS introductions and tasks, DfS principles and practices, DfS practices for eco-efficiency and eco-effectiveness and DfS practice for product durability.

Measurability tends to focus on quantity rather than quality in education and learning (Hiim, 2016, pp, 150–151). However, the qualitative results of the timekeeping records and the students' responses should not be read solely with an effect-oriented approach to education; instead, they should be viewed within the qualitative outcomes of the project. The data were limited to the understandings expressed by the students and do not account for additional sources of the students' knowledge, despite the transdisciplinary nature of the topic.

## The DfS educational practice and the student self-evaluation results

Organised according to the four overarching DfS themes described above, this section describes the educational practice outcomes, the students' engagement with the introductions and tightly structured tasks on the seven interpretive themes and the results of the student self-evaluations.

### DfS introductions and tasks

AG1 used 25 of their 27 total study hours on making the bentwood boxes and 2 hours on introductions and tasks related to the DfS principles and practices. During the craft-based design practice in lessons 1–17, the students primarily focused on making their bentwood boxes in the school studio. In these lessons, the DfS principles and practices were introduced by June and Tor when they found it expedient. This occurred in five lessons, i.e. lessons 1, 2, 3, 4 and 8, with an average duration of approximately 6 min (1 min 30 s, 10 min 30 s, 14 min, 1 min and 2 min, respectively, for a total of 29 min). These instructions all took place during decision-making situations about the design in sketches, work drawings and material selection.

The project book work in lesson 18 was held in a computer room. In this lesson, the students participated in 30 min of mutual introductions and 60 min of project book work (total 90 min). This included responding to tightly structured tasks to assess the environmental considerations related to their boxes, as well as uploading scanned drawings, work drawings and photos. In addition, the self-evaluation questions were completed, and the students had the opportunity to finish their project books at home. The coverage in lessons 1–18 of the introductions and tasks related to the DfS principles and practices is visualised in figure 2.

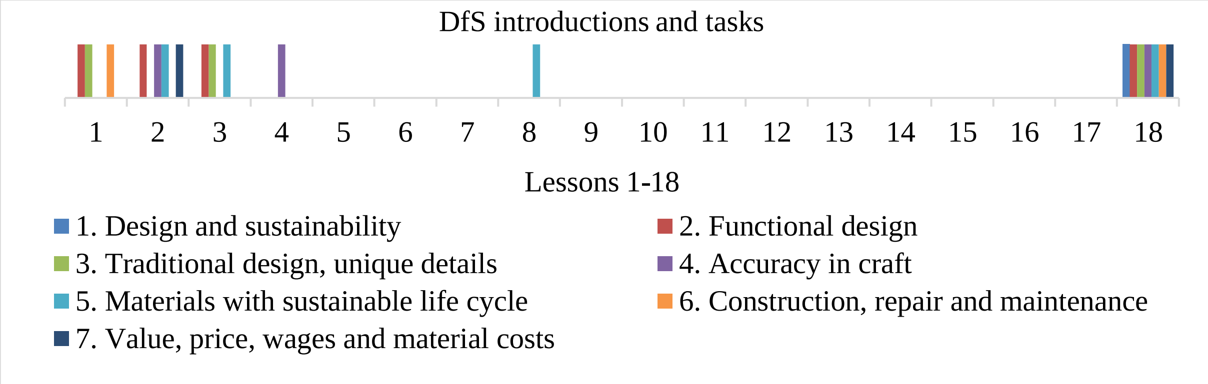


*Figure 2.* Clusters column chart on the coverage in lessons 1-18 of the introductions and tasks related to the DfS principles and practices.

According to their self-evaluation responses to the question, "Difficulties: Was there anything you experienced not being able to understand or manage in your work, and if so what was difficult?", the students found DfS to be understandable. The majority (n = 16) found nothing in the project they did not understand or manage, while a minority (n = 6) thought the details of the craft practice were difficult. None responded that DfS was difficult. Reading these responses in light of Edwards' (2015) model of task sequencing, the introductions and tightly structured tasks used in the present study successfully modelled ways of engaging with DfS in a craft-based design project to support student learning. The time allocated to the craft task supported the students in mastering the project's challenging and comprehensive craft practice. However, only a short time was spent on the project book work. June's evaluation of the project, documented in meeting memos, was that the students expressed little attachment to their project books after submitting them.

**DfS principles and practices**

Lesson 18 was the first and only time that June introduced the principles that guide DfS practices. She displayed the *design and sustainability* project book page on the projection screen, which was comprised of a SmartArt graphic of a segmented cycle of ecological, social and economic environments, with examples of product life cycles that support the sustainability of these environments. The graphic was based on the principles of LCT (Cooper, 2005; Heiskanen, 2002) and TBL (Elkington, 1999). It visualised examples of product life cycle impacts on environmental quality, social justice and economic prosperity, which could not otherwise be experienced in a school studio. Accompanying the image was one text box with bullets describing DfS practice (Cooper, 2005, 2010) and its intergenerational perspective (Keitsch, 2012). Another text box had bullets with information on unsustainable consumption in Norway (Fretex-gruppen, 2015), global population growth (UN, 2015b) and the idea that knowledge on product durability can help reduce consumption.

June drew on the students' experiences from the school studio to start a conversation on the graphic model. She asked what they remembered from their initial lessons. Ida referred to their talk in lesson 2 on materials with sustainable life cycle, saying, "I believe that it is to not use up the materials, that it renews itself later". June pointed at the ecological environment in the segmented cycle and confirmed the necessity of practicing sustainable material extraction from ecological resources. She explained the interrelatedness between production, use and disposal in ecological, social and economic environments. Another student responded that the economic aspects do not apply to their products, and June confirmed that their school-made products differ from professional products. Next, she pointed to the bullets on unsustainable consumption and population growth and reminded the students that they had designed their products to reduce the risk of them becoming waste. Other students brought up examples of sustainable and unsustainable situations in their everyday lives. The students expressed understanding. of the topic while they participated in the conversation.

According to the self-evaluations, the students found DfS to be relevant for their own design and craft practices. On the question, "Usefulness of knowledge on sustainability and design: In which situations do you believe you can make use of knowledge on sustainability and design?", the majority (n = 17) referred to their design and craft practices in general or in their present and future education or professional life. A small minority (n = 3) referred to sustainable consumption, while only one (n = 1) stated that the knowledge would not be useful. Reading these responses in light of Edwards' (2015) model, most students experienced being able to make connections between key concepts of the DfS principles and practices and apply these to their own craft-based design practices.

**DfS practices for eco-efficiency and eco-effectiveness**

In lessons 1–17, June and Tor introduced practical interpretations of DfS practices for eco-efficiency, with the low use of resources from cradle-to-grave (Cooper, 2005, 2010), and eco-effectiveness, with the circular use of resources from cradle-to-cradle (McDonough & Braungart, 2009, 2013). In lesson 2, Tor facilitated a conversation on sustainable extraction, use and disposal of wood, while presenting the beech and ash wooden materials for the bentwood boxes. Tor asked what attributes the students associated with sustainable materials, and Erik suggested, "That it is strong". Tor confirmed the role of material solidity in the product user phase. Then, he asked questions on the origin, extraction and disposal of wooden materials. The students cited the possibilities of deforestation from wood extraction and regrowth, further incineration and decomposition of disposed wood. In response, Tor explained how wood is a renewable resource when supported by sustainable extraction, replanting of trees over generations and recycling through decomposition. The students brought up examples of the unsustainable extraction of wood from rainforests, and Tor elaborated on this with an example of the use of rainforest teak in products used in Norway. In lesson 3, June returned to the selection of efficient and functional materials for the product user phase when she explained the importance of selecting a wood type that does not add smell or flavour, particularly in boxes used for food storage. In lesson 8, June briefly revisited material extraction and recycling when she introduced the rattan and leather tread materials for the box seams.

In lesson 18, June returned to the DfS practices for eco-efficiency and eco-effectiveness. She displayed the *materials with sustainable life cycle* page on the projection screen. A text box on the left side introduced the life cycles of beech and ash, including extraction, user qualities for bentwood products and, moreover, the use and composting of wooden shreds. It also covered joint materials, including rattan, leather thread and non-biodegradable Polyvinyl acetate (PVAC) glue, as well as surface treatment materials, including a non-toxic oil that does not turn rancid, to prevent staining, drying and breakage. A text box on the right side held tightly structured questions on the students' material choices for the boxes and joints and the benefits of these. It also included possibilities for composting and recovering energy from the boxes if they were disposed of at some point.

June started with a question on the meaning of the term life cycle. Ida responded that it means "From the start until the end, when a tree starts growing, until someone cuts it down and we throw it away. The growth, death and disposal of a tree." June confirmed and elaborated on this topic before she asked the students what other materials they had used in their bentwood boxes. The students mentioned and asked questions on the materials they had used; why they had treated their boxes with oil; suitable types of oils for boxes intended to contain food; and the possibilities of composting, incinerating or reusing materials from disposed wooden boxes that contain glue. Afterwards, the students responded to the questions in their project books; some expressed understanding of the challenges involved in composting glued wooden objects, while others found this question challenging. Rita wrote, 'Most of the box [materials] are wood, which means that it can be burned for heating and that it can be decomposed to soil. However, because the glue is plastic, it is not decomposable'. The students suggested cutting out and composting the parts without glue and incinerating or recycling the materials. They illustrated their materials by uploading a drawing they had made of the species of wood they had selected. For future student groups, ash will be substituted with other wood species. This because, during the year of this project, our data on the situation for ash became outdated. Due to a plant disease among trees, the status of ash was changed to vulnerable, the mildest grade of threatened species in Norway (Artsdatabanken, 2015).

According to the self-evaluations, the students associated design for eco-efficiency and eco-effectiveness with DfS rather than craft. On the question, "Problem solving for sustainable design: What is your experiential learning on choices in design, materials, construction and craft to reduce products' negative environmental impacts?", the majority (n = 17) referred to topics introduced in the interpretive theme Materials with sustainable life cycle. Their responses were distributed over all the life cycle phases, including extraction (n = 9), use (n = 6) and after use (n = 5). Meanwhile, on the question, "Craft: What is your experiential learning on the craft technique and the handling of materials and tools?", only a small minority (n = 2) referred to topics in the interpretive theme materials with sustainable life cycle. Reading these responses in light of Edwards' (2015) model, most students were able to recollect practices for eco-efficient and eco-effective use of materials in open-ended questions on DfS; hence, they would be able to try applying practices for eco-efficiency and eco-effectiveness in more open DfS tasks. In their task on the after use phase, they had already started engaging in open-ended problem solving activities involving combinations of materials in product design for recycling in ecological cycles through composting. The distribution of the self-evaluation responses over all life cycle phases could indicate that the DfS principle of the LCT on materials support their learning of DfS practices. However, the responses referring to the materials that were functional for the user phase, could also have been interpreted as referring to DfS practices for product durability.

**DfS practices for product durability**

In lessons 1–17, June and Tor introduced practical interpretations of DfS practices for product durability and long life span in the user phase (Chapman, 2009, 2010, 2015; Cooper, 2005, 2010; Stahel, 2010), while the students were designing their bentwood boxes in sketches and work drawings. In lesson 1, June told the students that they were to develop durable boxes and asked them how they could do that. The students responded that they had to make the boxes beautiful, solid and practical. In lesson 2, Tor told the students to plan their durable boxes by making a work drawing. Tina added, "If you are to make a box, than make a proper box, make it a little bit smart." Tor followed up with examples of planning the box in order to develop a functional size, avoid mistakes and dispose of half-finished products. Further, the intention of practicing skills and accuracy for development of emotionally valuable products. In lesson 3, June brought up design for functional and outer aesthetic product qualities. She asked students to read aloud from the project book text under the headings, *Functional design* and *Traditional design, unique details*. The students asked questions on the functional sizes and shapes of boxes to keep sewing equipment and cookies, which were the main intended uses of their boxes. Then, June explained how to develop unique designs in the traditional technique through sketches and work drawings. In lesson 4, June revisited the topic of product durability by asking about the purpose of planning a product. The students replied that the purpose was to develop a product with which they were satisfied. June responded that this could increase the likelihood of their keeping the product rather than disposing of it.

In lesson 18, June and the students returned to DfS practices for product durability. Five interpretive themes each headed a page in the project book; each theme had one text box with an introduction and another with tightly structured tasks.

The *functional design* theme introduced a practical interpretation of Stahels' (2010) description of the design of product qualities in functional tools to support product longevity. According to this theme, unpractical products are rapidly replaced and cause unnecessary product disposals. Further, bentwood boxes is traditionally used for the storage of small garments, decorative objects and food. The tasks for this theme concerned the students' planned use of the boxes and their design of the functional size and shape for the intended use. The students intended to use their boxes as containers for cookies, bakery items and other types of food, as well as for knitting equipment and silver jewellery for traditional costumes. Some had planned their boxes as decorative artefacts, and others had not decided on an intended use. Rita wrote, "I intend to keep cookies and Christmas cakes in it. I have designed the box for cookies, not too large but not too small either." The students illustrated the design with a scan of their work drawings.

The *traditional design, unique details* theme introduced a practical interpretation of Coopers' (2005) description of the design of outer aesthetic product qualities in crafted details to support product longevity. According to this theme, products we dislike and those which lack attachment are rapidly replaced. Further, historical trends in the decoration of bentwood boxes were introduced. The tasks for this theme concerned the design of the box details. The students described their decoration choices for the shapes of the seams, lids and locking mechanisms, as well as the selection of materials for the seams. Gina wrote:

> I made the locking mechanism reach all the way down. The lid is plain, without dramatic details. The overlap is shaped as a jigsaw-puzzle piece. The seam runs in a straight line down the middle. The only thing I regret is not using a fair colour on the seam to camouflage it more.

They illustrated their designs with detailed photos.

The *accuracy in craft* theme introduced another practical interpretation of Coopers' (2005) description of the design of outer aesthetic product qualities, such as signs of quality, to support product longevity. According to this theme, accuracy gives the box a professional appearance. The tasks for this theme concerned the craft details that the students considered to be of good quality and those they could have performed better. The students described the accuracy in the shape of the seam, the lid and the locking mechanism, along with the vertical positioning of the locking mechanism. Paul wrote, "I think I managed to make the locking mechanisms as I planned. But, I could have made the bottom of the box better, as it became uneven." They illustrated the quality of their crafts with detailed photos.

The *construction, repair and maintenance* theme introduced a practical interpretation of Coopers' (2005) description of the design of intrinsic product qualities, such as robust, carefully assembled and repairable construction, to support product longevity. According to this theme, products that are not solidly constructed or those that are difficult to repair or maintain are rapidly disposed of by users. The tasks for this theme concerned the construction of solid joints, weak points, possibilities for construction improvements and maintenance methods. Most students described the locking mechanisms as the weakest part of their boxes, and they also described how to maintain their boxes with oil. Magnus wrote, "The top of the locking mechanisms are slim, so these are the weakest points. One can glue them back on." They illustrated the topic with photos of the box joints.

The *value, price, wages and material costs* theme introduced a practical interpretation of Coopers' (2005) description of production for product longevity and sustainable consumption. Moreover, Chapman's (2009, 2010, 2015) description of design for emotionally durable living objects, enhanced through gifts and memories, was also incorporated. The introduction of this theme focused on the earlier mass production of bentwood boxes, along with the costs and social consequences of today's mass production of storage boxes. In addition, emotional product value, independent of product price, was described. The tasks for this theme concerned the calculation of the production costs for the bentwood boxes, based on the material costs and an hourly wage example. Moreover, the students were asked why price examples for similar handmade and machine-made sales products were so much lower than the production costs of their boxes. Furthermore, the students were asked about whether they intended to keep their bentwood boxes or give them as gifts. The students expressed pride for and emotional attachment to their boxes, which they intended to either keep for themselves or give or share with family members. As Gro wrote:

> I might have used more time on it than was used on the one in the craft store. Then, it becomes more expensive because I have put more work into it, and the box I made is not mass-produced, so it is only one, and it is mine.

According to the self-evaluations, the students understood design for product durability, but associated it with craft rather than DfS. On the question, 'Problem solving for sustainable design: What is your experiential learning on choices in design, materials, construction and craft to reduce products' negative environmental impacts?', only a small minority (n = 2) referred to an interpretive theme within design for product durability; both of these respondents referred to accuracy in craft. Meanwhile, on the question, 'Craft: What is your experiential learning on the craft technique and the handling of materials and tools?', the majority (n = 22) expressed acquired learning craft practice for product durability. Most of these respondents (n =20) referred to accuracy in craft, while some (n = 4) referred to construction, repair and maintenance. Reading these responses in light of Edwards' (2015) model, most students were not applying design for product durability to open-ended DfS questions. Hence, they were unlikely to apply these in more open tasks involving open-ended problem solving activities with ambiguity and risk.

### Possibilities and challenges

The students' self-evaluations reveal possibilities for the students' development of design literacy for sustainability. They found the DfS principles and practices comprehendible and relevant for their design and craft practice, education and future work.. However, they associated practices in design for eco-efficiency and eco-effectiveness with learning DfS, but they associated practices in design for product durability with learning craft. A comparison of this result with the timekeeping of the students' engagement with the different introductions and tasks, moreover their expression of understanding throughout the project does not explain this difference. However, as Jean McNiff (2013, p. 18) wrote, action research leads to new and interesting questions. This outcome indicate that the students found it more challenging to develop design literacy for sustainability on design for product durability than on design for eco-efficiency and eco-effectiveness. However, aspects of possible influence on the student experiential learning are the distinct characteristics of these DfS practices.

## Discussion

The different characteristics inherent in design for product durability and design for eco-efficiency and eco-effectiveness may have influenced the students' learning. To visualise the differences, the students' engagement in these DfS practices is outlined in a modified version of a model for DfS educational practices (Maus, 2017), which employs Klafkis' (1959/2001, 1985/2001, pp. 101–184) perspectives on holistic knowledge development through student (the subject) engagement with an educational topic (the object). The triangular model (Figure 3) visualises the students' engagement with the DfS practices to reduce the school studio design products' (present object) negative environmental impacts (absent object), which were absent from the school studio. With the aim of designing products with low negative environmental impacts, the influence between the design products and the environmental impacts was bidirectional with both affecting each other.

The practices used in design for product durability and design for eco-efficiency or eco-effectiveness employ different approaches to reduce products' negative environmental impacts. Design for eco-efficiency and eco-effectiveness seeks to reduce products' direct environmental impacts, while design for product durability seeks to reduce products' indirect environmental impacts by changing user behaviours regarding product acquisition, use, disposal and replacement. The triangular model (figure 3) visualises the implications of these different practices on students' engagement in the DfS and *development of design literacy for sustainability*.

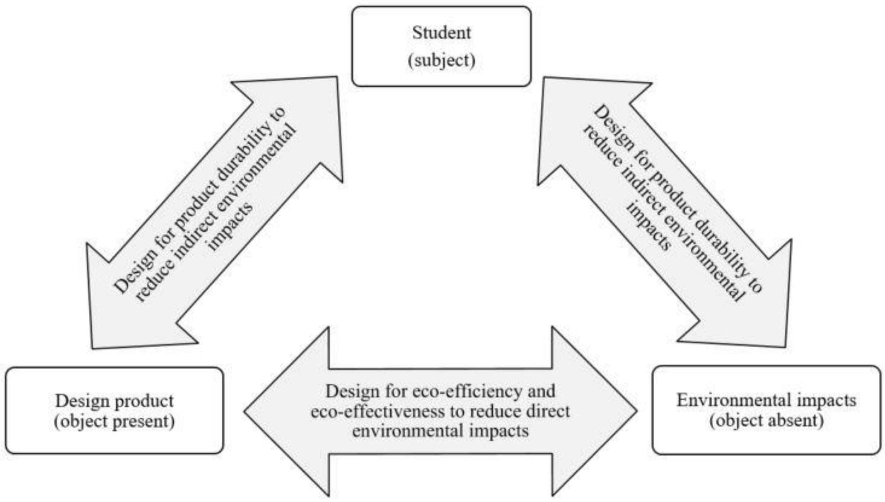


*Figure 3*. The model displays a variation in the use of the model for educational practice in DfS (Maus, 2017), which visualises engagement in design for product durability versus eco-efficiency and eco-effectiveness.

**Design for product durability**

Design for product durability involves the engagement of design qualities to achieve a positive and long-lasting relationship between the design product and the user, with the aim of reducing indirect environmental impact from disposal and product replacement. Chapman (2010, 2015) describes the subject-object relationship and focuses on design for emotionally durable products. Several product qualities, including intrinsic, functional, outer aesthetic and emotional qualities, affect the length of a product's life span. In design for product durability, the students engaged in the relationship between the design product (present object) and the product user—in this case, the student him/herself (subject)—to prevent the user from negatively impacting the environment (absent object) (figure 3).

Possibilities to enhance design literacy in design for product durability were present in the bentwood work, including designing product qualities that support a lasting relationship between a product and its user. The product qualities were experienced and observed by the students during their design and craft process. Thus, tangible examples and participation in DfS practice were present throughout the craft-based design project. Introductions of objective general ideas and questions for subjective critical thinking, judgement, will and imagination on these examples (Klafki, 1959/2001, 1985/2001, pp. 101–184) were developed with support from the research on design for qualities of durable products. This case study shows that the students expressed understanding during their engagement with the examples. Moreover, the students acquired knowledge and skills in the creation of durable products. However, challenges were equally embedded in this part of the case study. The focus on creating a lasting subject-object relationship between the design product and the subject drew the focus away from the environmental context of the potential indirect environmental impacts caused by the user. Thus, only a small minority of the students' responses referred to design for product durability as part of their acquired DfS learning, their competence in this area does not match their competence in creating durable products. Hence, further engagement with the influence between the student and the environmental impacts are required.

The purpose of enhancing the students' design literacy in design for product durability is the application of sustainable development in their craft and design practices and their everyday lives. The environmental benefits of reducing resource throughputs in the user phase are supported by research on the indirect environmental impacts of product replacement (Ivanova et al., 2015). However, sustainable consumption requires knowledge, skills and values. The characteristics of durable products can be experienced during acquisition, use and repair. Design knowledge of these characteristics and their significance in reducing indirect environmental impacts can provide youth with autonomy in self-determination and co-determination and solidarity in the development of sustainable societies. In addition, reducing consumption depends on initiatives for redistributing employment from production to repair and service to avoid a recession (Cooper, 2005). Such initiatives will require co-determination and solidarity among the public. Thus, the practice of design for product durability is essential to the purpose of general education in design and ESD.

**Design for eco-efficiency and eco-effectiveness**

Designing for eco-efficiency and eco-effectiveness involves engagement in design with the aim of reducing products' direct environmental impacts. With reference to Chapman's (2010, 2015) description of the subject-object relationship in emotionally durable design, design for eco-efficiency and eco-effectiveness is described here as design for an object-object relationship. In design for eco-efficiency or eco-effectiveness, the students engaged in the relationship between the product (present object) and its environmental impacts (absent objects) (figure 3). Design for eco-efficiency seeks to reduce negative environmental impacts by minimizing the use of resources, including materials, water and energy, throughout the product life cycle from cradle-to-grave. Eco-effectiveness aims to recycle and generate resources throughout the product life cycle from cradle-to-cradle. Both design practices are guided by the principles of LCT and TBL.

The possibilities to enhance design literacy in design for eco-efficiency and eco-effectiveness are substantial. The focus of these DfS practices is on saving material resources to reduce the direct impacts of material use on ecological, social and economic environments. In the design for the user phase of the product life cycle, some eco-efficiency design practices can coincide or be combined with design for product durability, e.g. in this case study, the functional materials for the user phase. Other design practices can be irrelevant, e.g. in this case study, reducing energy and water usage in the user phase. The students in this case study expressed their understanding through engagement with examples of efficiency or effectiveness in material use, though not all of their suggestions were technically feasible. The students' engagement with the question concerning whether their glued wooden box could be composted demonstrates how craft-based design provides examples of ways to engage in feasibility and the need to develop materials and products for material recycling in ecological and technical cycles. The students learned about the use of materials throughout the product life cycle, which they considered relevant for their future. Challenges were equally embedded in this part of the case study. The focus on the flow of material resources in the product life cycle and the materials' environmental impacts reduced the design products to the sum of their materials. This focus concerned the object-object relationship between the design product and the environment, overlooking other aspects of environmental impact, such as the subject-object relationship between the design product and its user or how product use affects environments. Leaving out the product user might seem convenient if the user does not want to change his/her behaviour. However, general education should not suggest that sustainable development does not involve product user participation or even expect that the public would prefer not to participate in sustainable development. After all, designing product qualities for the user phase in this case study enhanced student engagement.

The purpose of enhancing the students' design literacy within eco-efficiency and eco-effectiveness also concerns the application of sustainable development in their craft and design practices and their everyday lives. General education in design for youths aims to prepare them to participate as citizens in the development of sustainable societies (Digranes & Fauske, 2010); consumption cycles are a major aspect of this participation. In product encounters, the knowledge, skills and values of youths concerning eco-efficient and eco-effective use of materials throughout the product life cycle will fundamentally influence their ability to practice sustainable consumption. The risk of eco-efficiency leading to green growth with a high throughput of resources with an overall loss of resources rather than a savings (Cooper, 2005) is a possible challenge. Therefore, enhancing design literacy in eco-effectiveness and eco-efficiency serves, but does not fulfil, the purpose of general education in design and ESD.

## Conclusion and the path forward

The possibilities to enhance design literacy for sustainability through DfS are numerous. Design literacy develops through engagement in the design and craft process in the environmental context of influences between design products and environmental impacts. Support for engagement with this environmental context, which cannot be observed during craft-based design practice in school studios, is to be found in the principles and practices within the professional DfS field. DfS practices for eco-effectiveness, eco-efficiency and product durability can be employed in tasks that are of less complexity then the problem solving practiced by professional designers. General education in DfS should facilitate students' participation *in* craft-based DfS practice at their level, rather than just teaching knowledge *about* professional DfS. Through practical work, with examples illustrating objective DfS principles and practices, students can use their subjective critical thinking, judgement, will and imagination to develop their design literacy for autonomy, self-determination, co-determination and solidarity in sustainable development.

In this case study, introductions and tightly structured tasks were employed to engage the students in DfS, with them expressing that they found DfS to be understandable and useful for their design and craft education and future work. Nevertheless, there were indications that the students were further along in their development of design literacy in DfS practices for eco-efficiency and eco-effectiveness than for product durability. They associated their learning of design for eco-efficiency and eco-effectiveness with DfS, but were unable to make the same association between DfS and product durability. One possible reason for this is the different characteristics of the DfS practices.

This case study responded to a call for empirical studies in the field, and the results were encouraging. However, DfS education is a broad field, and this case study only covers a few approaches. Therefore, further inquiries are recommended. In addition, the current highest priority is increasing competence in DfS education among teachers with subject specialisations in Art and Crafts, as these are the professionals who must translate the ideology of sustainability in design into educational practice to enhance design literacy for sustainability.

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