# The Quality of Design in 9th Grade Pupils' Design-and-Make Assignments in Craft Education

Erja Syrjäläinen and Pirita Seitamaa-Hakkarainen, University of Helsinki, Finland

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The aim of the present study was to analyse the performance of grade 9 pupils (15-16 years old) on a design-and-make assignment, which was a part of the assessment of learning outcomes conducted by the Finnish National Board of Education (FNBE) in crafts. A sample of the students' work on the assignments (N= 169) was analysed from the viewpoint of visualization and operationalisation of the design ideas. Further, the functional and aesthetic aspects of end products were evaluated. The method of qualitative and quantitative data analysis of the pupils' design-and-make assignment is explicated in detail. The results showed that pupils had difficulties designing on paper; they executed only very basic line-work for the designed products, and only some details were illuminated in their visual representations. The poor quality of visual and technical designing revealed that the objectives of the National Core Curriculum in craft education have not yet been attained. Further, these results also indicate that the pupils' skills in clarifying their visual designs do not necessarily directly relate to the functionality of what they have concretized in the end products. The implications of the study for craft education are discussed; brief recommendations are made on how craft should be taught at school and what should be emphasized in the courses' content.

**Key words**
craft education, visual design, technical design, design-and-make assignment, assessment of learning outcomes

**Introduction**

In Finland, craft education (also called sloyd education in the Scandinavian context) has had an official and equal position with other school subjects for over 150 years; as far back as that, Uno Cygnaeus introduced craft education as a compulsory school subject for basic education. The National Core Curriculum for Basic Education 2004 defines craft education as a school subject, one with units, and prescribes compulsory crafts, consisting of textile and technical work. Craft as a standard school subject is a unique phenomenon from an international point of view. Equivalent school subjects with similar kinds of objects may be mentioned, for instance Design and Technology in UK, Sloyd in Sweden, and a combination called "Design, wood, metalwork and home economics" in Denmark. In many countries, such as Estonia, Latvia, or, for instance, Japan, craft is included in Home Economics (textile work), and Technology (technical work). In Finland, craft education is a compulsory subject in elementary level (grade 1 to 6, ages 7 to 12) and at the lower secondary level, grade 7. In the grade eight to nine (ages 14 to 16), students can select craft education as an optional subject. The core curriculum for craft education highlights values and aims that relate to creativity and problem solving, technical and aesthetic skills, independent working skills and promotion of self-expression. Further, the holistic and iterative nature of craft processes is emphasized; particular attention is given to the ideation, testing and making as well as the reflective and evaluative aspects related to craft (FNBE, 2004: 242; Pöllänen, 2009, 2011). However, many educators have expressed critical concerns that craft education in Finland puts more emphasis on making, on practical processes more than on artistic processes (Karppinen 2008; Pöllänen, 2011).

Craft education has special significance in promoting human creativity and innovation, particularly when conceptual ideas and material aspects of the process reciprocally support one another (Kangas, Seitamaa-Hakkarainen & Hakkarainen, 2013). The design process is essentially included into craft processes, and craft is seen as the way to materialize design thinking. However, the National Core Curriculum 2004 does not give any detailed guidelines about the teaching of craft education or the detailed content to be covered, materials and techniques to be used. The broad formulation of the craft curriculum might make it more demanding for the teachers to plan their teaching according to nebulous aims. Although the holistic craft process is stressed in the curriculum, the teachers might still rely on tradition that emphasises the practises of functional skills needed in the making processes (traditional craft techniques and craft products) instead of developing creative ideas (Pöllänen, 2009; Karppinen, 2008). Pöllänen (2009) has also pointed out that especially elementary level teachers (grade 1 to 6) have difficulties in understanding the concept of holistic craft process. On the other hand, the broad curriculum aims give freedom to teachers and they may be more motivated, creative and autonomous to develop means for craft education. The main objectives and contents of craft education are summarized: 1) pupils learn to use tools and materials purposefully; 2) pupils learn to design functional, aesthetic and quality products as well as various visualizations and documentation techniques (i.e., sketches and mock-ups); 3) pupils learn to make useful and aesthetic products; they learn the basic craft methods and techniques as well as ways to carry out holistic craft processes including self-evaluation and evaluations of other pupils' works (Laitinen et al, 2011).

The central idea of the present article is to illustrate the important role of visual and material representations in craft education. In the following, we will highlight the value of craft education by emphasizing, first, the complex design tasks and design constraints related to design processes; and, the important role of the various representations in the materialization of design ideas. Secondly, we will introduce the general results of the assessment of learning outcomes conducted by the Finnish National Board of Education (FNBE) in crafts in the final 9th grade of the basic education in 2010. Thirdly, based on the design-and-make assignment (N= 169) data collected as a part of this national evaluation, we will introduce our own data analysis of this pupils' production assignment. Finally, we will discuss the implications of our study for craft education. This bears relevance to the question of how craft should be taught at school and what should be emphasized as the content of craft education.

### Complex design tasks and role of various representations

Craft and design education provides pupils important opportunities to work with complex design tasks within meaningful learning contexts (Hennessy and Murphy, 1999). Design problems are characteristically ill-defined and require the integration of knowledge across domains, as well as implementation of conceptual ideas in the design of materially embodied artefacts (Cross, 2004; Hennessy and Murphy, 1999). There is no right or wrong solution for a design problem, only more or less satisfactory solutions. Due to the complexity of the design task, designing involves the integration of several skills and competencies; it therefore has the potential for enhancing both content knowledge and reasoning capabilities (Puntambekar and Kolodner, 2005). In designing, pupils are concerned with the usefulness, adequacy, improvability, and developmental potential of ideas (Bereiter and Scardamalia, 2003); they develop knowledge and skills to model, design and give form to ideas in physical artefacts.

Designing is generally considered a complex long-term creative problem-solving process; i.e., design ideas emerge gradually as a process of structuring and restructuring the problem, defining and redefining the constraints of designing, and generating and testing solutions (Goel, 1995; Cross, 2004). The complexity of the design process emerges from its cyclical and iterative nature, and thus, the possible solutions arise from a complex interaction between parallel refinement of the design challenge and the design ideas (Lawson, 2006; Seitamaa-Hakkarainen & Hakkarainen, 2004). Further, designing includes extensive visual and technical skills, as well as intensive, domain specific knowledge (Goel, 1995). The design and making of the product illustrate the inter-relationship of conceptual, procedural and embodied knowledge in the design of artefacts. In the design process, visual and technical design elements must be related to each other, within the constraints, in order to create a functional and aesthetic solution (Seitamaa-Hakkarainen & Hakkarainen, 2001).

A pivotal aspect of the design process is the gathering and utilization of domain-specific knowledge, in conjunction with the visual and technical characteristics of the desired product. Seitamaa-Hakkarainen & Hakkarainen (2001) have proposed that the design process may be characterized as a dual-space search through composition and construction spaces, as in many other areas of problem solving. Composition space, the use of which is seen as a domain-independent design process, consists of the organization of the visual elements and principles selected and manipulated during the design process. Construction space, the use of which is seen as a domain-specific design process, consists of the organization and manipulation of the various technical elements and principles. The selection of the visual elements requires a search through the composition space, and the selection of technical elements requires search through the construction space (see Figure 1).

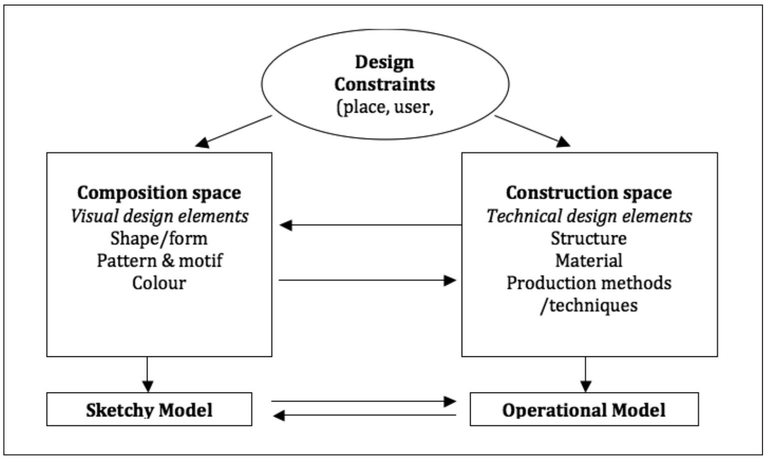


*Figure 1. Composition and construction design (Seitamaa-Hakkarainen & Hakkarainen, 2001)*

Figure 1 depicts design problem solving as a process with two components: composition and construction design. The design task and design constraints frame the design process; connecting a visual idea to its technical realization provides the final end product. Explicating only the visual elements produces a *sketchy model* of the designed product. In order to realize the visual design characteristics, the technical aspect should also be solved; creating the operational model of the designed product (Seitamaa-Hakkarainen & Hakkarainen, 2001).

A review of the research literature examining the role of sketching for design professionals shows that sketching has a crucial role in generating, developing, and communicating ideas; it is both a powerful form of thinking and the fundamental language of design (Welch et al, 2000). Designing cannot be reduced to merely playing with ideas; in order to understand and improve the ideas in question, they have to be given a material form by means of practical exploration, drawing and prototyping (Hope, 2005; Rowell, 2002; Welch et al, 2000). In the early stages of designing, visualization helps to define and clarify the task and explicate the needs constraining the task. Furthermore, visualizations and sketching facilitate the evaluation of ideas and elaboration of the design task. Through visualization, design ideas, proposed solutions, and decisions are made explicit and visible.

Visualization is not only drawing on the paper, the term covers the use of various forms of representations (for example material collages) and mediums. Professional design activities rely on the use of various tools and design representations, such as sketches, models and notes (Goel, 1995; Al-Doy and Evans, 2011). Pei, Campbell and Evans (2010) have developed taxonomy for various representations used in the various phases of the design process that consists of 32 representations of various kinds, from idea sketches to pre-production prototypes. Numerous external representations (graphical and physical) in various phases of the design process provide different kinds of prompts to test the design ideas. In the context of Design and Technology education, the interaction with two- and three-dimensional models has offered pupils direct possibilities to explore and evaluate the form and function of a proposed solution (Hennessy and Murphy, 1999; Rowell, 2002; Welch et al, 2000). However, research has shown that children rarely use two-dimensional models, but tend to move immediately to three-dimensional modelling (Hope, 2005; Rowell, 2002; Welch, 1998). Although dealing with material issues and making products are considered to be crucial aspects in craft learning, it is important to find balance between conceptualizing and developing design ideas in visual representations as well as experimenting with actual materials. In craft education this means that students' should be encouraged to visualize their ideas and the teachers need to provide enough time for that. In the following, before presenting our own research on the quality of design-and-make assignment outcomes, we will provide a general overview of the results of the Finnish National Board of Education's learning-outcomes assessment in art and craft subjects. This overview provides the general context of our own study.

**The National Evaluation Study**

For the first time in 2010, the Finnish National Board of Education assessed learning outcomes in art and craft subjects (music, visual arts and crafts) in the final grade (9) of basic education. At the end of grade 9 the pupils are approximately 16 years old and they will usually continue their studies in upper secondary school (high school)) or vocational education. The assessment of the learning outcome study (Laitinen et al, 2011) was conducted for educational policy reasons in order to evaluate how all pupils who are completing their compulsory education have developed those skills and objectives presented in the National Core Curriculum for Basic Education in arts and crafts. Similar national studies that were based on random samples of students, based on questionnaires, attitude forms and paper-and pencil tests, have been carried out in Sweden in visual arts (Lindström, 2006).

In the National Evaluation study the data were collected from 152 schools across Finland; virtually all ninth-grade students (total students: N= 4792) participated in the assessment of learning outcomes (Laitinen et al, 2011), whether they had participated compulsorily or voluntarily in the music, visual arts or craft. The national evaluation study consisted of four assignments. First, a common pencil-and-paper assignment dealt with questions from all three subjects. The assignment was based on the standards of pupils' basic key skills and knowledge of the subjects derived from the core curriculum. The second assessment – an advanced pencil-and-paper assignment – required more sophisticated interpretation and understanding of these subjects. Third, a survey related to the pupils' opinions of studying and learning these subjects was completed. Finally, production (i.e., design-and-make) assignments projects that required making music, visual arts or craft item was conducted (Laitinen et al, 2011). All pupils participated in common pencil-and-paper tasks and a survey. For the second stage, the schools were divided into three groups (about 50 schools in each group) and in each school the pupils completed advanced pencil-and-paper assignments either in music, visual arts or in crafts (N= 1548). In 48 schools, pupils (N= 661) completed a design-and-make assignment in craft.

The results of the assessment of learning outcomes revealed, first, that the pupils' performance in music, visual arts and crafts varied considerably and was quite uneven, depending on subject (Laitinen et al, 2011). Second, learning outcomes in craft education were, however, adequate or satisfactory; 21% (N= 1014) achieved excellent results, and 34% (N=1998) received good results in the common pencil-and paper assignments. Yet a considerable proportion of pupils failed to command the contents of the key skills and knowledge areas derived in the common pencil-and paper assignments (Laitinen et al, 2011). In the advanced pencil-and-paper assignment only 8% received excellent results, and 19 % got good results in crafts. Third, the results revealed evidently that those pupils who had studied crafts as an optional subject in grade 8 or/and grade 9 achieved significantly better results. Statistically, they were especially better at the tasks that related to tools, materials and techniques due to the fact that they have spent more time in craft education. In general, the pupils' attitudes toward studying craft were mainly positive.

There were no significant differences between the sample schools regarding the general learning outcomes in crafts. The outcomes were quite even between girls and boys; however, the boys performed better in technical crafts than girls whereas the girls were better in textile crafts (Laitinen et al, 2011). The learning outcomes, for both genders, in the common pencil-and-paper assignment were better in tasks that related to tools and materials and poorer in tasks that covered product-making techniques (Laitinen et al, 2011). However, as stated earlier, in craft learning the unique qualities of the holistic craft process strongly relate to the problems being solved. In the design-and-make assessment, the pupils' product-making skills were found to be stronger than their designing skills, which were considered the weakest (Laitinen et al, 2011). Because the National Curriculum for Basic Education emphasizes the skills involved in visualizing design ideas and using various visualizations and documentations techniques, it was quite surprising that the pupils' performance of design-and-make assignment was evaluated as merely satisfactory (or less) on average.

For that reason, the aim of the present study was to analyse grade 9 pupils' performance on a design-and-make assignment at a more detailed level. We analysed the same design-and-make assignment data again that were collected during the national evaluation (FNBE, 2010) from the different viewpoints. Our research was conducted separately and addressed three main questions:

1. What is the level of performance in pupils' visual and technical design?
2. What are the respective evaluations of the functional and aesthetic aspects of the end products of the design-and-make assignment?
3. How are the qualities of visual and technical design connected in the end products?

**Method**

As stated earlier, the National Board of Education conducted a specially tailored design-and-make task in 48 schools in 2010. An average of 13 pupils in each sample school carried out the task. The schools were directed to send examples of three pupils' production assignments, including sketches and plans related to their work, to the National Board of Education. These works represented, respectively, examples of excellent (best), moderate (average) and poor (worst) performance on the production assignment, as evaluated by the teachers in that particular school: 41 schools provided these three examples, 7 schools sent 6 examples (three in textile work and three in technical work), 1 school provided 4 assignments. In total, our data consisted on 169 pupils' designs (i.e., sketches), end products and written self-evaluations of the craft process. We analysed this data separately from the national evaluation study although the data was the same in both cases. The design brief of National Evaluation study for the design-and-make assignment was the following:

PRODUCTION ASSIGNMENT: TIME 180 MINUTES

1. DESIGN and PRODUCE a craft product where you can keep one of the following objects: mobile phone, MP3 –player, USB-stick, headset or glasses. You can design individually or in a group. Your final design needs to be individual. It should not be similar to someone else's.
   Take into the consideration where the product will be used: will it be on the table, on the wall, on a belt, on a bookcase, or will it be hanging? Your product could be a prototype or operation model for further developing.
2. DESIGN AND SKETCH the picture of the product,

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you can clarify your drawing by written text (for example measurements, materials etc). You can use 20-30 minutes for designing and sketching.

3. EXPLORE the material selection available in the class (different fabrics, felting wool, different yarns, timber, wood sheet, wood lath, plastics, leather and thin metal sheet).
4. MAKE the product. When your Design is ready, move to the textile or technical class to make your product
5. EVALUATE your product and compare it against your design.



Before presenting our data analysis method, it is important to notice that in the National Evaluation study the design-and-make assignment evidently emphasised making the product and did not give so much importance to visual and technical designing aspects. The total time allowed for the designing (only 1/6 of the total time) confirms this. One must also consider that the total time includes the time taken to generate an idea.

**Method of data analysis**

We first carefully analyzed all design-and-make assignments and pupils' designs. Qualitative content analysis was conducted according to theoretical and data-driven approaches. In developing the classification scheme, we adapted the taxonomy of Pei et al (2010) for types of design representations and the complexity-level classifications of Rodgers et al (2000). First, the main division was made between 1) sketchy model (visual aspects) and 2) operational model (technical aspects) presented in the theoretical section. It should be noted that both of these aspects might be rendered in only one representation. Further, we analyzed the practicality and aesthetic qualities of the end products.

The *sketchy model* was defined to consist of shape/form, colour and detail designing related to the visual aspects of the item in question. The simplest drawings were monochrome line drawings, no shading to suggest three-dimensional forms, and no text or numerical annotations were included. The more complex sketches provided more variations in developing the shape or other details of the object and gave more information about the appearance. The operational model was defined as depicting the technical specifications of the product, i.e., explicating its structure, size, scale or measurement, and providing some information about production procedures or working methods. The sketchy model and operational model were ranked on a five-point scale (see Table I)

In order to analyze the practicality and aesthetic qualities of the end products, we utilized the FEA-model (Functional, Expressive and Aesthetic), concentrating only on the functional and aesthetic aspects (Lamb and Kallal, 1992). The functionality was based on our evaluation of how well the end product would work for the intended purposes. The classification scheme for functionality and aesthetic quality of end products is described in Table II.

The classification schema was developed for this study and would not necessary fit all craft design projects. In creating categories, it was important that the whole scale

| Value | Description of sketchy model |
|---|---|
| 1 | Only the simple line-work of the product was provided (correspond to idea sketch), no detail information in visual or written form. |
| 2 | Mainly simple monochrome line drawing but some details were explicated at some level. |
| 3 | Sketching of shape, details are explicated in personal fashion (correspond to study sketch). |
| 4 | More detail solutions were provided. |
| 5 | Developmental sketching with variations of shapes and details (correspond to referential sketch). |
| **Value** | **Description of the operational model** |
| 1 | Structure of the product was outlined, no scale, measurements or annotations. |
| 2 | Product line-work with some detailed illumination of the structure was presented. |
| 3 | More explicated structure, drawing may be annotated by describing certain technical aspects of the product. |
| 4 | The structure, proportion, scale and measurements were explicated in detail. |
| 5 | Clearly explicated structure including description of details, scale, exact measurement and some technical details provided (for example, working method written down). |

***Table I. Classification of sketchy and operational models.***

| Value | Functionality of the product |
|---|---|
| 1 | Will not work in practice – bad functionality |
| 2 | Based on some solutions, the functionality might suffer |
| 3 | Based on some solutions, the functionality might suffer |
| 4 | Quite functional |
| 5 | Very functional and practical |
| **Value** | **Aesthetic quality of the product** |
| 1 | No intention for aesthetic considerations |
| 2 | Intention toward aesthetic qualities, but not realized |
| 3 | Some aesthetic dimension perceived |
| 4 | Indented partial aesthetic solutions in details and shapes |
| 5 | Aesthetically good unity, colours, shapes in harmony – consistent style |

*Table II. Classification of the end product*

(1-5) could be used, and that the plans or designs, as well as end products, could be classified accordingly. Once the categorization was developed, the actual classification process was quite simple. An inter-coder reliability check for 20% (N= 43) of the designs and end products was conducted. The inter-coder reliability varied from .84 to .90, which can be considered satisfactory. The data analysis was conducted using the SPSS statistical program.

**Results**

In general, most of the pupils designed various kinds of storage containers for mobile phones (N= 126), and some combined storage for mobile phone and headset (N=12). Only a few pupils designed containers for the MP3-player, USB-stick, headset or glasses. Five pupils did not explicate the purpose of the container at all and two mentioned something else than what was suggested in the design brief. The results revealed that most of the products were to be used on the table (N=91), hanging on the neck (N=38) or belt (N=19) and as combinations of these (N=13) --especially products made of textile materials. The material selection varied from textiles to rigid or synthetic materials (like wood or metal); approximately half of the products were textile materials.

Table III presents the mean and variation of the level of the sketchy model, operational model, functionality and aesthetic of the product. The results revealed that 92% (f=155) of the sketchy models and 82% (f= 138) of the operational models reached only the values of 1 to 3. The majority of the sketchy models reached only the simple line drawing (scale 1) or provided some elementary levels of explication of some details (scale 2). Only a very few of the pupils received the value 4 that represented developmental sketching. The operational models (technical design) were slightly more advanced, however only 23 (13.6%) pupils received value 4 in the operational model. The functionality of the product was estimated slightly higher (mean 3.3) than the aesthetic quality of the products (2.9); however, the variance within functionality was higher than other aspects. The value of the product's functionality was estimated higher (5), for 19.5% (f=33) of the cases. To summarize, in general, the end products were functional, but the pupils' designs (sketches) did not have a very high quality.

| | Sketchy m | Operation m. | Functionality | Aesthetic |
|---|---|---|---|---|
| Number | 169 | 169 | 169 | 169 |
| Mean | 2,1538 | 2,5385 | 3,2544 | 2,8698 |
| Variance | 1,821 | 1,119 | 1,727 | 1,400 |

*Table III. The mean and variance of production assignment.*

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| | Sketchy m | Operation m. | Functionality | Aesthetics |
|---|---|---|---|---|
| Sketchy model | 1 | .671(**) | .407(**) | .531(**) |
| Operational model | .671(**) | 1 | .410(**) | .427(**) |
| Functionality | .407(**) | .410(**) | 1 | .715(**) |
| Aesthetics | .531(**) | .427(**) | .715(**) | 1 |

** Correlation is significant at the 0.01 level (2-tailed).

***Table IV. Correlations between sketchy model, operational model, aesthetics and functionality of the products.***



Table IV reveals the correlations between the designing (i.e., sketchy model and operational model) and the evaluation of the end product, based on functionality and aesthetics. The results indicate that the correlation was weakest between functionality and visual and technical design (.407 and .410). In addition, the correlation between technical design and aesthetic was weaker (.427) than other aspects. In other words, detailed designing did not automatically guarantee a practical outcome. Or, the other way around, a good and practical end-product was preceded by poor design presentation. These results provisionally show that the pupils' skills in explicating their visual designs do not necessarily directly relate to the functionality of what they have concretized in the end products.

To conclude, the results revealed that the main part of the outcomes, specifically, the end products, of the production assignment reached levels of satisfactorily/moderately functional or very functional. The results showed quite poor results in the designing on the paper; pupils reached only the level of very basic line-work of the designed products, and only some details were specified in the sketchy or the operational models. It should be noted, however, that in the National Evaluation study time limit for the designing was very short, and the emphasis of the design-and-make task was evidently on making the end products and did not particularly stress the importance of visual and technical designing. Considering the time limit, the pupils might have been afraid that they would not finish main task (product) of which they can be accountable. It seems to us that the aesthetic aspects of the end product were not so important for the pupils as their functionality. By looking at the end products, we can conclude that there were some attempts to create personal products and to develop details; our analysis shed some light on that process.

## Discussion

The organization of such nation-wide testing as was carried out in Finland, is very exceptional and quite demanding for subjects such as music, visual arts and crafts. Lindstöm's (2006) study clearly revealed how difficult it is to develop assessments, criterion-referenced judgments and a grading system to evaluate students' creativity and innovativeness. Similar concerns may be directed at the learning-outcome assessment in Finland. We believe that more process-based assessment ought to be carried out in order to reveal the iterative nature of designing processes, however, it requires deeper theoretical frameworks as well as extensive empirical testing of the assessment tools (Nieker, Antkiewicz and Swardt, 2010). In Finland, the design of a variety of assignments is very difficult since the National Core Curriculum does not explicate the specific contents (materials or techniques of designing and making) that should be taught in crafts. The whole area of textile and technical work is very broad, consisting of various techniques and working methods, covering both traditional and contemporary techniques, content knowledge of various materials, which creates extra challenges to design reliable assessment tools for learning outcomes. Further, as we have stated, this assessment of learning outcomes in crafts evaluated all ninth graders of the sample schools across Finland, not only those who had studied crafts as optional subjects in 8th and/or 9th grade. In other words, some pupils had studied craft as a compulsory subject from 1st to 7th grade, whereas others had studied two years more (Laitinen et al, 2011). From this viewpoint, the moderate results in respect of learning outcome among such a large group of pupils, is comprehensible.

The aim of the present study was to shed light on how well the aims and objectives presented in the National Core Curriculum related to visual and technical designing were achieved. The core curriculum states that pupils should be able to design "purposeful, aesthetic and quality products as well as learn to use various visualizations (i.e., sketches, mock ups etc), presentations, reporting and documentations techniques" (FNBE, 2004). The moderate quality of sketching that this research found, clearly reveals that these objectives have not yet been attained. However, as stated earlier, the given design-and-make assignment had its own biases: the task clearly revolved around completing the product and did not stress the developmental aspect of sketching. It is reasonable to believe that because of the time limit, the pupils might have been afraid that they would not finish the main task. Further, the results in this study might also confirm Welch et al's (2002) results; pupils may not see sketching as adequate and not see drawings as useful mainly in depicting the outcome; hence they may see no reason to sketch an object before making it. All participants produced a sketch, but we are not able to confirm how useful they considered sketching. It would have been valuable if we have had possibilities to interview the pupils about their design process. Nevertheless, it is probable that pupils have not been taught to practice visualisation as a tool for developing design ideas; and craft education still emphasises craft techniques, materials and product making. Students as well as craft teachers need to learn the meaning of the sketching as a vehicle for design thinking (Hope, 2005). As the research shows, the value of the subject in developing exploratory and creative thinking in schools is considerably underdeveloped and we still have a long way to go to realizing the full creative potential of craft education.

The holistic and iterative craft process is well emphasized in the National Curriculum for Basic Education, and consequently, in craft learning the unique qualities of holistic craft process strongly relate to the solving of complex problems. However, the design brief and the setting in the National assignment did not give time for reflection and iteration of ideas. Designing is not only limited to the ideation phase but also includes analysis of design context and design constraints. The careful analysis of design context or design situations and the understanding of the design constraints is a very important part of the designing. In the present study, the design context was partly explicated in the design task, but pupils were not required to do any analysis of the design constraints. Hence, in our data, we were not able to analyse how the pupils dealt with them. Prior research (Kangas, Seitamaa-Hakkarainen, & Hakkarainen, 2013), however, indicates that supporting students in defining and concretizing the constraints helps the students to deal with the infinity of the design problem space and the ambiguity of the design process, and to focus their attention to relevant aspects of the problem space.

We would argue that learning holistic craft process (i.e., designing, making and evaluating) is very important for children's development, and craft education has a lot of potential to offer for innovative learning. Craft education has enormous potentials to provide direct experience of new materials and technologies. However, at the same time, craft and design activities should develop the ability to enhance and transform ideas through the visualization, provide opportunities for imaginative solutions, and confidently expressing ideas on paper (Hope, 2005). The future challenge for teaching holistic craft process is how to find a balance between designing and making and to find new ways of facilitating various representational skills and documentation. Pupils should be encouraged to use different kinds of visualization, build models, and construct computer visualizations. Also, more emphasises should be put on the design portfolios that describe and document the whole design and making process.

This research is a first effort to verify the role and balance of design and making in a school subject called craft, on a national level. The systematic comparison between the design sketch and the end product has shown us a deficiency in some specific design skills. There is clearly need for new pedagogical approaches that are envisaged to encourage pupils in developing their design thinking and teasing out ideas and design possibilities. The teachers generally are very competent dealing with the construction stage. The challenge of craft education is how much time is allocated to design visualization and how is creativity being approached in design tasks. Recently, a new National Core Curriculum for Basic Education in 2016 is under construction and it will point out future directions for craft education. For that reason, we would like to propose, from an educational perspective, some significant aspects to be taken into account in enabling the pupils to become more confident in their development and visualization of design thinking:

- Teachers need to become more aware of design's character and task in the holistic craft process. Designing and design thinking is intellectually challenging (compared to easily caught and grabbed making) and requires special efforts and pedagogy from the teacher. Because of its demanding nature, design also has a strong developmental influence on pupils.
- In design processes the vast possibilities of solving the composition, construction, and constraint space problems call for teachers' kit of pedagogical scaffolding. The ability to define and offer pupils reasonably-sized problems and, thereof, structure the learning process so that the pupils experience the process as personally involving, is vitally important.
- The time and place of design in holistic craft process needs closer/more careful determination in relation to the learning objectives. The variety of proceedings and time managements has different kinds of impacts on pupils. The teacher needs to be aware of this diversity and use it purposefully to ensure meaningful progress in designing and making.

- Craft education should offer various design contexts and tasks that require solving a diversity of the different aspects – from purely technological problems to design of functional or user-centred objects toward more art-related self-expression tasks.
- Providing collaborative design projects. The challenge for craft education in Finland is that the origins of design problem are too often narrowed to the pupil's personal needs. The challenge is to provide design problem is that its origins and priorities should also reside outside the personal context so that it supports multidisciplinary and collaborative working.

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erja.syrjalainen@helsinki.fi

pirita.seitamaa-hakkarainen@helsinki.fi