Design and assessment in technology education – case: the "Birdhouse Band" project

Tuomo Leponiemi
University of Jyväskylä
Department of Teacher Education
tuomo.t.leponiemi@jyu.fi

Sonja Virtanen
University of Jyväskylä
Department of Teacher Education
sonja.virtanen@jyu.fi

Aki Rasinen
University of Jyväskylä
Department of Teacher Education
aki.rasinen@jyu.fi

Abstract

According to the Finnish National Framework Curriculum one of the objectives in technology education (craft, technical work) is to develop pupils' designing skills. However there are no detailed criteria how to assess these important skills and therefore teachers have to determine those by themselves. Assessment without clear criteria tends to drive teaching towards promoting "guaranteed" and "safe" solutions that stifle pupils' creativity and independent thinking skills. One of the objectives in technology education is that pupils should learn technological problem solving skills. This objective requires teachers to engage pupils in technological problem solving activities. The design process is regarded as a learning strategy and through this pupils obtain systematic, sustained and independent working skills.

Instruction in technology education is implemented through projects corresponding to the pupil's stage of development. Methods of experimentation, investigation, and invention should be practiced actively. Starting points for projects can be found from everyday life problems, artefacts and materials. The technological problem solving process encompasses phases of setting out the problem/task, exploring possibilities, brainstorming, from a chosen idea to planning an accurate solution, realizing the project and testing and evaluation.

In order to improve assessment of designing in technology education, a model was developed that works as a pedagogical step-by-step tool to enhance the design process. This tool serves two purposes: first, for the pupils to develop their metacognitive skills about the design process and their ability to self-assess, and also for the teacher to be able to assess the process. The model is demonstrated by one case: the "Birdhouse Band" project, as an example of applying the technological problem solving process.

Introduction

It is essential to teach pupils to solve problems and encourage them to think independently, because it can be seen already that creativity, innovativity, critical thinking, responsibility and self-directness are qualities that are needed now and definitely in the future in modern society. (Oivallus, 2011; Parikka & Rasinen, 1997.) Self-directed and process-oriented citizens are more likely able to cope with the rapidly changing and situated knowledge in the societies, and, thus, the school should teach the skills needed in the world of today and in the future (Huhta & Tarnanen, 2009). In short, learning to solve problems in everyday-life or a pedagogical method namely "starting point approach", could be used to support pupil's development in various skills listed above. Technical craft (technology education) could provide possibilities for pupils to concretely learn these important skills. However, one key problem is the assessment practice in craft education. It seems that too often the teacher assesses only pupil's product at the end of the process though assessment should support pupil's self-directed and process-oriented learning throughout the whole learning process.

In Finland there is no subject called technology or design and technology. Since National Core Curriculum for Basic Education 2004 (NCC), there has been a cross-curriculum theme called "Human being and technology". It is one of the seven themes that should be considered in all subject areas. Craft is an individual subject area in the comprehensive school (compulsory at grades 1–7 and optional at grades 8 and 9) and it comprises contents of textile craft and technical craft. Many objectives and contents of the cross-curriculum theme "Human being and technology" and technical craft are overlapping. Based on our experience and analysis of NCC technology is mainly taught during technical craft lessons (Rasinen, Ikonen & Rissanen, 2008). Therefore, in this paper we refer mainly to technical craft in context of technology education.

Assessment can be seen as a road sign for learner that guides their learning process. Traditionally, such guidance is provided mainly by teacher, accordingly teacher's assessment practices at the classroom. Teacher-led agenda that does not allow the learner to have an active role in working can lead to missed learning opportunities, and to a failure to develop learner autonomy and the skills needed in the modern world. Despite the development of new socio-constructivist theory of learning that has become the predominant view that underlies instruction in many countries, assessment practices often lag behind and continue to be based on old models of learning and curriculum design. (Huhta & Tarnanen, 2009.) Based on our experience this is still the reality in too many schools. In technology education pupils are making products by copying the product that teacher has designed and created.

Assessment in the Finnish context

During the time of comprehensive school system (same education to all from grade one to grade nine), since 1970 there has been no national testing of pupils. Some national tests for instance in mathematics and languages are available, but it is up to the teacher or school to decide if she or he wants to use them (Salmio, 2004). The emphasis in assessment has been to give guidance to the pupils rather than authorizing marks at the end of the term or academic year. Instead of marks (from 4 to 10) pedagogical discussions take place. Also parents are invited to schools to attend these sessions. Pupils are given written assessments instead of marks only, particularly, in lower grades. At the end of grade nine all pupils are given marks from 4 (fail) to 10 (outstanding). For this there are statements about good performance in the NCC 2004. Previous NCC 1994 did not give any instructions on assessing, but the National Board of Education published separate guidelines on pupils' assessment. In craft education teachers have been encouraged to evaluate the whole learning process from planning to the final artefact since 1970, but it seems that still today only the final product is assessed by many teachers.

According to the NCC 2004 instruction in craft (technical craft/technology education) should be implemented through projects corresponding to the pupil's stage of development. Methods of experimentation, investigation, and invention should be practiced actively. One of the objectives in technology education is that pupils should learn technological problem solving skills and this requires teachers to engage pupils in such type of activities. Starting points for projects can be found from everyday life problems, artefacts and materials. The technological problem solving process encompasses (should encompass) phases of setting out the problem/task, exploring possibilities, brainstorming, from a chosen idea to planning an accurate solution, realizing the project and testing and evaluation.

One of the objectives in craft is to develop pupils' designing skills. However, NCC document doesn't advocate any detailed criteria how to assess these important skills and therefore teachers have to determine those by themselves. Assessment without clear criteria tends to drive teaching towards promoting "guaranteed" and "safe" solutions that stifle pupils' creativity and independent thinking skills. If designing is not regarded as a part of a learning strategy, pupils will not go through the whole process and therefore they will not obtain systematic, sustained and independent working skills. When speaking about design or designing in this paper an emphasis is on the process.

A model of designing in technology education

Technology means activities, but what kind of activities and processes do we find in technology? And what kind of methodological approaches should be used to teach these processes for children in a comprehensive school? In general technological processes can be design processes, making processes and processes in the phase of using and assessing technology. (de Vries, 2005, 49.) Because of the history of craft education in Finnish primary and secondary schools, pupils are still too often making products by copying the product that teacher has designed and created. Education like this, gives no place for pupil's designing skills or how to develop them.

In reflecting on design process, design methodologists more and more became aware of the complexity of design problems because of the many influencing factors. Adjusted to primary level, following four types of factors (de Vries, 2005, 54) may be taken into account when planning the design task in school:

- Scientific factors: the natural phenomena on which the functioning of the product is based
- Technological factors: the materials and processes that are available
- Market factors: the ideas that the customer/user have about the product (in schools normally the user is the student him/her self)
- Ethical and environmental factors: materials used when making the artefact

In order to improve assessment of designing in technology education, we as primary school teacher educators wanted to develop a pedagogical model to introduce and test it with our technology education (teacher education) students. The model (Figure 1) was developed based on two various models which describe the stages in the design process (Garratt,1996, 6–11; Layton, 1993, 45–48). We modified Garratt's and Layton's models to better suit in Finnish technology education. We also added criteria for each stage that describe students' activity in a design process. The model works as a pedagogical step-by-step tool to enhance the design process in technology education. It both guides the students to develop their metacognitive skills about the design process and their ability to self-assess, and gives the possibility for the teacher to be able to assess the process. The idea is that the teacher must adjust how to use this model to match the grade level at school. For example at grades 1–4 the steps 2, 3 and 5 could be combined or skipped according to the task. The model describes accurately "steps", which pupils and the teacher can follow. By going onwards through the steps pupils can follow their working and reflect what is already done. For the teacher it is possible to assess at the same time both the whole process and various "steps". Every step has its own criteria for assessing and therefore the final grading consists of several markings.

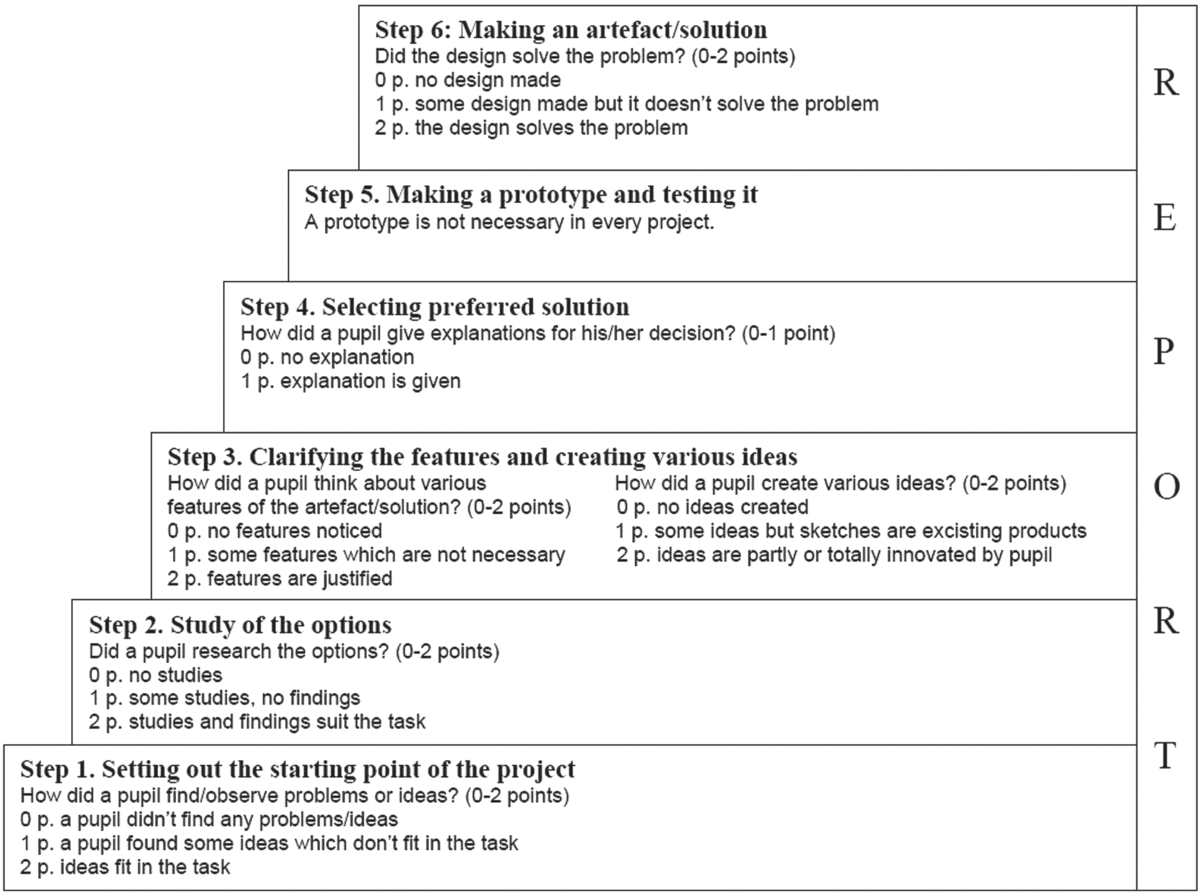

Figure 1. Development of pupil's designing skills

Developing pupils' designing skills is one of the objectives in technology education. There are no detailed criteria how to assess these important skills so teachers have to determine those by themselves. This model is suggestion for teachers how to assess pupils' development of designing skills. The model illustrates the design process step by step with detailed criteria and points in scale 0–2 in each step (altogether maximum 11). On the other hand the model enables pupils' self-evaluation during design process. In the following we will describe each step with assessment criteria.

Step 1. Setting out the starting point of the project. The first step of the model demonstrates how pupils are guided to observe and find the starting point for the project. We have categorised the starting points for three different approaches: projects that 1. solve "everyday life"/abstract problems, 2. are some kind of artefacts and 3. are created of certain material/s (wood, metal, textile etc).

- Assessment criteria of designing: How did pupil find/observe problems or ideas (0–2 points)? The level of how open ended the problem or task is, must be adjusted according to pupil's age.

Step 2. Study of the options. The second step demonstrates how pupils make a little study about the options for different kinds of solution and what has already been made for same kind of purpose as the starting point of the project indicates. Pupils are encouraged to find many solutions, which are somehow connected to starting point. The purpose is that pupils come up with some ideas probably from existing products, but they should develop the idea further. When observing the options pupils could take photos or/and sketch.

- Assessment criteria of designing: How did pupil study the options (0–2 points)?

Step 3. Clarifying the features and creating various ideas. At this phase pupils are guided to think about the artefact they want to create and the features that they need to take into account when designing it. They are guided to draw 2 or 3 sketches of the artefact/solution they would like to create. It is important to encourage pupils to sketch freely and guide them to think about the design to the direction of what kind of artefact/solution would solve the problem.

- Assessment criteria of designing: How did pupils come up with various features of the artefact/solution (0–2 points)?
- Assessment criteria of designing: How did pupils create various ideas (0–2 points)?

Step 4. Selecting preferred solution. At this phase of the process pupil will choose one of the sketches and make a (technical) drawing of it. He /she has to explain why that sketch is chosen. By arguing, pupil has to think about the whole process, what has been done and what should be done next.

- Assessment criteria of designing: How did pupil give explanations for his/her decision (0–2 points)?

Step 5. Making a prototype and testing it. When the (technical) drawing is ready, pupil will make a prototype, if needed. When testing the prototype pupils are guided to find both strengths and weaknesses of the product she/he has designed. There are no assessment criteria at this phase, because making a prototype is not necessary in every project.

Step 6: Making an artefact/solution.
The final product will be made following to possible prototype. Pupil will assess whether the product corresponds to an original task.

- Assessment criteria of designing: Does the design suit the task? (0–2 points).

In the end, pupils will write a short report with reflections of the whole process from the beginning to the end. The written notes of each step work as a learning diary and they form a basis for the final report. By writing a brief report pupils will reflect the decisions they have made and describe their working. When pupils think about the process step by step they are able to understand the meaning of all the steps (particularly designing) which lead to the final outcome.

The tool serves two purposes: first, for the pupils to develop their metacognitive skills about the design process and their ability to self-assess, and also for the teacher to be able to assess the process. In the following section the use of the model is demonstrated through a pilot study, case the "Birdhouse Band" project realised by teacher education students. The main idea was that the students were guided to practise metacognitive skills and the process was not assessed this time. The "Birdhouse Band" project works as an example of the above described strategy of designing in technology education.

Case: the "Birdhouse Band" project

We chose to introduce the model first for the group of students that studied to be class teachers (at grades 1–6) and also specialized to technology education. The model was introduced for the students at spring semester 2010 when they started to plan their group-projects of integrating technology with the perspective the group chose themselves. At this stage the model was used only for students' self evaluation of the process, but it was not used for grading the students' work, only to enhance designing and metacognitive skills.

Starting point for the project was set out as a question like "In what are we good at?" and "How would we like to develop technology education in school?" These students had chosen to specialize in technology education and this type of a project was a part of their studies. Duration of the project was approximately 30h. In the following one of the projects, the "Birdhouse Band", is presented.

Step 1. What is the problem we need to solve? The first step in the problem-based project was to set out or find the "problem or task". Students in the technology education course were guided to choose their problem freely and the task was set out to be very open ended. Students were encouraged to put their knowledge of materials and tools into practice, and to find their "problem" or idea in a group by themselves. The "Birdhouse band" group, three male students started with an idea of creating something that has generally been done in schools, a birdhouse, in a new way. So the problem became to be to change the tradition.

Step 2. How can we solve the problem? At the second step students were guided to make a small study about the options for different kind of solution. All three of the students in the "Birdhouse band" group liked music, to play guitar, bass or drums, so they got the idea of making instruments to look like a birdhouse. They started to design their instruments on the basis that the instrument looked like a birdhouse box and decided who would like to create and play it. Each member of the group started to design the instrument he would like to create. The main idea was, that the group worked together and helped each other, but at the same time was responsible for making one's own instrument.

Step 3. What kind of features needs to be taken into account when designing the artefact/solution? At this phase students were guided to study about the artefact they wanted to create. One way to do it was to make a list of features that they need to take into account. The "Birdhouse band" group studied different kind of guitars and drums on the Internet and picked up important features, which were necessary for playing them. For building a drum there was a ready-made model of *cajon,* which inspired the drummer to mix the cajon's shape and a birdhouse. The criterion for this instrument was that it should be acoustic. The guitar player noticed that it was possible to make a lap steel to look like a birdhouse. Bass guitar player noticed that the bass needed to be something else, than just a box, because the sound had to be lower than guitar sound has. So it became clear that bass had to have a neck. Both "lap steel birdhouse" and "bass birdhouse" needed to have instrumental microphones.

Step 4. Choosing one of the sketches and drawing a detailed technical drawing of it. The Birdhouse group had studied their instruments and noticed the features so that in technical drawings the lap steel was designed to take the pulling of the strings and there was the place for the microphone. The bass needed the neck because of the low sound and there was the place for a microphone, too. In the bass one wire was enough because of the thickness of it. The drum had to have two kinds of sound, higher and lower, so in technical drawings the frame was designed in the way that two kinds of sounds were possible to play.

Step 5. Making a prototype and testing it. Building instruments demanded the group to test different kind of solutions during the process. According to the defined features and drawings, students built their instruments without prototypes because the instruments themselves were like prototypes and solutions needed modifications and planning all the time. One example of testing was that the group found instruction to build an instrumental microphone and they built the prototype, which was actually the part of the final artefact.
Step 6: Making the artefact/solution. Does the design solve the problem? The group tried to get a solution that suit the problem "How to create something that has generally been done in

schools, a birdhouse, in a new way" and they achieved their aim. The students built three "birdhouse box instruments" and they performed as a band playing a classic rock song "Smoke On The Water". Watch the Birdhouse Band playing: http://www.youtube.com/watch?v=AoGRARlKNog (or write Lintupönttöbändi in youtube).

Discussion

It can be seen already that creativity, innovativity, critical thinking, responsibility and self-directness are qualities that are needed now and definitely in the future. (Oivallus, 2011; Parikka & Rasinen, 1997.) Technology education could provide possibilities for pupils to learn these important skills by working concretely with various tasks. One key problem is that the assessment practices in Finnish craft (technology) education tend to drive teaching towards promoting "guaranteed" and "safe" solutions that stifle pupils' creativity and independent thinking skills. In order to improve assessment in technology education, we developed a pedagogical model namely "Development of pupil's designing skills" and demonstrated it by one case created by teacher education students: the "Birdhouse Band" project.

Finnish NCC 2004 states that instruction in technology education should be implemented through projects and methods of experimentation, investigation, and invention should be practiced actively. The model introduced in this article may encourage teachers to instruct pupils' working with open ended projects so that pupils can work creatively and innovatively. By observing different kind of solutions according to the task and planning their own project, pupils are guided to make decisions and give arguments. This also serves the purpose of developing pupils' critical thinking, when pupils have to consider the design they want to create according to materials and techniques they can use. The design process is divided into smaller steps that may help pupils to work self-directly. Therefore it can be assumed that it also raises pupil's responsibility of her/his work. For the teacher this model serves as a tool to assess pupils' working with detailed criteria.

Even though this model is only a suggestion for teacher educators and teachers to enhance designing in technology education this could form a useful starting point for further research of pupils' development in designing or assessment of a design process. The next step for us as teacher educators would be taking up the gauntlet of studying students' development of designing skills.

References

Garratt, J. 1996. *Design and Technology.* (2nd ed.) Cambridge: Cambridge University Press.

Huhta, A. & M. Tarnanen 2009. *Assessment practices in the Finnish comprehensive school – what is the students' role?* In May, S. (Ed.) LED2007: Refereed conference proceedings of the 2nd International Conference on Language, Education and Diversity. Hamilton, New Zealand: Wilf Malcolm Institute of Educational Research (WMIER), University of Waikato.

Layton, D. 1993. *Technology's Challenge to Science Education.* (Developing Science and Technology Education.) Buckingham: Open University Press.

National Core Curriculum for Basic Education. (2004). Helsinki: National Board of Education.

National framework curriculum. (1994). Helsinki: National Board of Education.

Oivallus -project. 2011. Oivallus final report. www.ek.fi/oivallus/en [1.3.2012]

Parikka, M. & Rasinen, A. 1997. *From product assessment towards assessment of learning processes and self-assessment.* In I. Mottier & M. de Vries (Eds.) Assessing technology education. Proceedings PATT-8. Netherlands.

Rasinen, A, Ikonen, P. & Rissanen, T. 2008. *From craft education towards technology education : the Finnish experience.* In W. G. Lewis & H.G. Ff Roberts (Eds.) Design and technology in the curriculum. Bangor university: School of Education.

Salmio, K. 2004. *Examples of National Basic Education Evaluation Programmes* From the Perspective of the Didactics of Sustainable Development. University of Joensuu: Joensuun yliopiston kasvatustieteellisiä julkaisuja, no 98 [Educational publications of University of Joensuu], no 98.

de Vries, M. J. 2005. *Teaching about technology. An Introduction to the Philosophy of Technology for Non-philosophers.* Dordrecht, The Netherlands: Springer.