Crafting Maths: Exploring Mathematics Learning through Crafts

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Abstract
This article introduces a project in a Finnish secondary school where mathematics education was combined with crafts instruction. The idea was to provide the students with an interdisciplinary real-world learning context in which they worked collaboratively on an open-ended design task. The approach was problem-based and student-centred in a way that Neumann (2013) describes to be *in* and *with* students. The teacher's role was to allow the students to self-generate their learning and to work in partnership with them. The students were given a rather open-ended, ill-defined design task that required them to take risks, find information and collaborate. The student interviews (N=17) after the project revealed that their attitude to mathematics had become more positive. They began to understand the connections between these school subjects in an authentic learning environment. They learned to solve problems and combine theoretical and practical knowledge. Their understanding of the importance of mathematics in real-world situations increased. The project demonstrates how to arrange teaching and learning in a more holistic way instead of in a traditional subject-based approach. This kind of interdisciplinary approach demands good cooperation from both the students and the teachers. For interdisciplinary education to be further developed, support is needed for the teachers to collaborate and learn new teaching approaches.

Key words
mathematics education, craft education, technology and design, interdisciplinary teaching, student-centred learning, problem-based learning

Introduction

Interdisciplinary teaching and learning is one of the main concepts in the present discussion about efficient and meaningful learning (Laurie, 2010; Parker et al, 2012; Savage, 2010). It is also central to the ongoing renewal of the National Core Curriculum of Basic Education in Finland (Finnish National Board of Education [FNBE], 2014). In this article, we introduce an interdisciplinary project in which Mathematics education was combined with Technical Crafts instruction in a Finnish comprehensive school. The idea was to encourage learners to make cross-curricular connections while working on a project in which they needed to apply mathematics when constructing an apparatus in which energy was produced or needed. The approach followed the ideas of the pedagogy of STEM subjects (Science, Technology, Engineering, Mathematics), which aim to combine the teaching and learning of these subjects in a meaningful way through a Problem Based Learning (PBL) approach (Capraro et al, 2009; Gibson and Bell, 2011; Spendlove and Barlex, 2011). In this case, the subject area of Technical Crafts was combined with Mathematics using a student-centred approach.

The Finnish National Core Curriculum for Basic Education is rather diverse in terms of the variety of the subjects the students need to study. The idea is to give the students a broad understanding of the world and develop their various potentials and skills within different knowledge fields. (FNBE, 2004.) Until today, teaching and learning has mainly been subject-based and the teachers are relied upon to present each subject's special field of knowledge. The so-called academic subjects, and the more practical and artistic subjects form separate modules in the National Core Curriculum. Although interdisciplinary teaching and learning is widely accepted in Finland, as an important approach for meaningful learning, it has remained unclear how to implement this in practice.

As teachers of Crafts, Mathematics and Science, we understand that the curricula of these subjects share common goals, and thus wanted to provide the students interdisciplinary real-life learning context in these studies. Looking at the examples of STEM and PBL teaching in other countries (Brears et al, 2011; Capraro et al, 2009; Gibson and Bell, 2011; Spendlove and Barlex, 2011), we were interested to determine whether an interdisciplinary approach would have any impact on the students' engagement with and motivation and attitude towards their studies. We were especially concerned about students' motivation to mathematics learning, which has internationally proved to be low compared to other countries (Liu and Lin, 2010; Mullis et al, 2008; Spendlove and Barlex, 2011). Furthermore, in Finland, Mathematics does not seem to be among the most popular subjects (Jakku-Sihvonen, 2013:11). Reasons for students' low motivation have been examined and attempts to find methods to improve their attitude have been developed (cf. Wu and Huang, 2007; Francisco, 2013). Our small-scale project gives an example of an experiment to improve students' attitudes toward studying mathematics and also to develop their understanding of the connections between different subject areas.

Mathematics and craft education in Finnish Basic Education

Before introducing the project of this study overall, we will clarify some aspects of its Finnish educational context. The Finnish National Core Curriculum for Basic Education determines the many aspects, contents and goals of the compulsory nine year basic education curriculum (grades one to nine, years 7-15) (FNBE, 2004). Mathematics is one of the main core subjects in Finnish compulsory education; it is taught in 3-4 lessons per week depending on the grade (FNBE, 2004). Finland has always scored one of the highest positions in the world wide comparisons on educational achievement, such as PISA[1], and the country has gained a reputation as an "education superpower" (BBC, 2012). However, in the latest TIMMS[2] evaluations, the Finnish pupils' success in mathematics was lower than earlier, and their motivation to study mathematics was one of the lowest in these comparisons. This has motivated the decision makers to look for more suitable and pupil-centred pedagogical methods to teach mathematics (Ministry of Education, 2012). However, already according to the 2003 PISA results, the development of effective learning was one of the major pedagogical challenges and goals of the Finnish comprehensive school (Välijärvi et al, 2007).

A study conducted by Eurydice gives an overview from 30 European countries of the state of artistic and cultural education in compulsory general education. At the primary level, grades one to six, all pupils have some compulsory arts education (Eurydice, 2009:15.) Crafts is included in the arts curriculum in nearly two-thirds of these countries (Eurydice, 2009:26). However, in most European countries craft education is integrated into the curriculum of such subjects as Arts, Home Economics or Technology and Design (T&D). Scandinavian countries are exceptional in this regard since Crafts (also called Sloyd) is a standard subject in their comprehensive schools (Gulliksen and Johansson, 2008). This reflects the value craft/sloyd education is given in the Scandinavian countries as a means of promoting pupils' holistic education (Pöllänen, 2009).

In Finland, Crafts is a standard core subject that is compulsory for pupils mainly in grades one to seven (age 7-13, about 2 lessons/week). In the upper grades of the comprehensive school, grades eight and nine, studying crafts is optional. From the third school year onwards, teaching concentrates on specialized techniques with different materials, either textiles or hard materials like wood and metal. Accordingly, craft education has mainly been arranged in two separate fields, Textile Craft and Technical Craft (approx. 2 hours/week)[3]. The present National Core Curriculum for Basic Education (FNBE, 2004) leaves it to the local schools and municipalities to decide how to organize the studying of these two subject areas (see Kokko, 2009, 2012). In our project, we applied the field of Technical Craft education to studying Mathematics in a Finnish comprehensive school.

Craft education in the Finnish comprehensive school has deep roots dating back to the beginning of its school system in the 19th century (Autio et al, 2012:116). Thorsteinsson and Ólafsson (2014) have researched the roots of pedagogically oriented craft education which was based on the ideas and work of Otto Salomon (Sweden) and Uno Cygnaeus (Finland) and also Axels Mikkelsen (Denmark). These pioneers' views of the importance and meaning of sloyd education were spread to the Scandinavian countries and also to the whole of Europe. Sloyd education stressed the importance of integration of body and mind in promoting pupils' development. However, these ideas were not fully adopted in the Finnish curriculum for comprehensive schools (Autio et al, 2012:116). The official name of the subject has changed through time from Sloyd to Crafts in Finland (see Metsärinne & Kallio, 2014:9). According to Sjöberg (2009:72), "the concept of 'sloyd education' in the Nordic countries is used as an umbrella term for different educational crafts".

The pedagogical objectives have changed considerably due to the social and cultural changes in Finland. Starting with the practical purposes of developing skills to make artefacts needed in every-day-life in the agrarian times; the focus of craft education nowadays concentrates on various other aspects. (Pöllänen, 2009; Rasinen et al, 2011). The objectives of present-day craft education cover such aspects as sustainable development, cultural awareness,

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[1] The Programme for International Student Assessment (PISA) is a worldwide study by the Organisation for Economic Co-operation and Development (OECD).

[2] The Trends in International Mathematics and Science Study (TIMSS) is established by the International Association for the Evaluation of Educational Achievement (IEA)

[3] At the time of writing this article, a curriculum reform is under way (FNBE, 2014). The preliminary draft of the Crafts curriculum suggests substantial changes to this subject especially in terms of teaching the two subject areas: the students will be learning 'multimaterial crafts' without choosing an area to concentrate on.

creativity, aestheticism, self-expression and a positive attitude towards crafts work. Skills in problem-solving, construction and design, the use of basic techniques and equipment, understanding of different materials, and safety aspects with craftswork are also emphasised (FNBE, 2004; see Syrjäläinen and Seitamaa-Hakkarainen, 2014). Considering the variety of objectives, it becomes clear that it is not possible to cover all aspects in each craft project at school; therefore, attempts to create pedagogical models to support the teachers' choices have been developed. The emphasis on craft education may vary in different craft projects from learning to use techniques and materials to learning designing, self-expression and problem-solving (Pöllänen, 2009, 2011; Syrjäläinen and Seitamaa-Hakkarainen, 2014). However, the idea of a holistic craft process in which the same person designs, makes and assesses his or her self-made artefact is widely accepted in Finnish craft education.

Mathematics and Crafts are often seen as very different subjects. They seem to differ between the following concepts: theoretical vs. practical, appreciated vs. less appreciated and unpopular vs. popular. Mathematics has always been one of the main subjects in the worldwide comparisons of students' excellence in different school subjects. This shows the high value placed on mathematics as a school subject. On the other hand, arts, design and technology education including crafts have lost significance in the curriculum of many European countries (Eurydice, 2009; Spendlove and Barlex, 2011), which is a sign that they are less valued than the so-called academic subjects. However, PISA research (Välijärvi et al, 2007) has revealed that although Finnish students appreciated mathematics, they thought it was unpopular and theoretical. In a national study about the students' attitudes and excellence in different subjects in Finland, it became clear that both girls and boys disliked Mathematics, as a school subject, although they both thought it was very useful. Quite the contrary, most art subjects were popular among the students. In the study, Crafts was regarded as a popular subject among both girls and boys; in fact, it was the most popular school subject among the Finnish schoolboys. (Jakku-Sihvonen, 2013:11–14.)

Although Mathematics and Crafts seem to differ in the above-mentioned ways, many common goals are to be found in the Finnish National Core Curriculum of these subjects (FNBE, 2004: §7.6 Mathematics, §7.17 Crafts). Both subjects share an objective of developing pupils' capacity to cope up with real-world situations. In addition, developing the pupil's creativity is mentioned in their curricula. More importantly, problem-solving processes and skills are highlighted in both the subjects.

Student-centeredness encompasses project-work at school

Student-centred learning (SCL), as a method to improve the learning process and outcomes as well as the students' control over their learning, has been a recent topic in the research on teaching practices in mathematics (Francisco, 2013; McCrone, 2005). In addition, in the teaching and learning of crafts, a student-centred approach is central (Pöllänen, 2009; Karppinen, 2008). However, SCL is a complicated concept that has been interpreted in several different ways. According to O'Neill and McMahon (2005), the interpretation of the term appears to vary between authors as some equate it with 'active learning', while others define it more comprehensively including ideas about active learning, choice in learning, and the shift of power in the teacher-student relationship. SCL has been defined by its tenets (Lea et al, 2003; Brandes and Ginnis, 1986) as a concept opposite to teacher-centredness (Kember, 1997; Harden and Crosby, 2000). In addition, students' autonomy is highlighted widely in the literature on SCL (Burnard, 1999; Zimmerman, 2002; Gibbs, 1995; Wu and Huang, 2007). According to Swan (2006:62–63), student-centeredness in teaching mathematics has meant that the students' needs are taken into account when deciding the teaching methods and contents.

In this article, the definition of SCL is based on Neumann's framework (2013); he describes three different kinds of student-centred relationships between students and teachers. According to him, student-centred learning contexts may be centred *in* students, *on* students, or *with* students. Learning contexts that are centred *in* students imply that learning dwells within the student and is generated with little or no assistance from anyone else. Within this context, educators simply need to avoid inhibiting learning, for learning essentially becomes self-generating and self-propelling. The second relationship, in which teaching is 'analogous to a kind of handicraft work', can be assigned the preposition on. "In this contour, teachers determine students' educational needs, and students react to those plans and prerogatives" (Neumann, 2013: 164). In this context, teacher's ability to convey the necessary material and student's responsibility to learn it are essential for learning. The third relationship, involving free beings, can be assigned the preposition *with*. Learning contexts centred with students bring the teacher into partnership with the student, implying that learning emerges as teacher and student collaborate. Neumann's (2013) framework raises many questions and he raises some of them himself. The most common student-centred context in schools today seems to be the on-students context. If the learning object is focused on a specific content to be learnt, the other contours (*in* and *with*) might not be as beneficial.

It appears that the contours *in* and *with* in SCL are to be highlighted, it is necessary to consider whether it is possible to learn mathematics without a common specific content and instead emphasise the process of learning mathematics as part of a real-world learning task. In our project, it was decided to experiment with the *in* and *with* contours in SCL and not define the specific and exact learning contents. Instead, the students were allowed to find and adapt the information and the skills that were needed in the projects that they had defined in their teams.

Research context, questions and methodology

The experimental pedagogical project was conducted with the Finnish 8th-grade students' (N=17; 8 girls, 9 boys, about 14-years-old) within their mathematics lessons. In addition to increasing their motivation in mathematics, the aim was to help the students understand and realize the interconnections between mathematics and other subject areas, especially technical crafts. For this reason, the students spent part of their mathematics lessons in a technical craft workshop where they were instructed to design and construct an apparatus or equipment that was somehow related to energy. Mathematics was to be applied in the planning and designing processes. The students were given a rather open-ended, ill-defined design task that required them to take risks, find information and collaborate (cf. Kangas et al, 2013). The students had full autonomy to decide about the process and how they wanted to organize themselves in teams. In addition, they had a possibility to study and practice 'ordinary' mathematics from time to time, instead of working on the apparatus in the craft workshop. The teams the students formed were named according to the apparatus on which they had chosen to work: Kite (3 girls, 1 boy); Wind turbine (2 boys, Figure 1); Hybrid pedal car (2 boys, Figure 2); Weather vane (3 girls); Motor (3 boys), and Motorised bicycle (2 girls, 1 boy, Figure 3).

The project began in mid-September 2011 and lasted about 25 weeks. The working period of the project was one school year covering 20% of all the mathematics lessons in the 8th grade. Instead of two regular 75-minute lessons of mathematics per week, the students were to spend one lesson in the crafts classroom working on the integrated project and another lesson studying ordinary mathematics. The mathematics teacher and crafts teacher cooperated in organising the work.

The purpose of the study was to determine what kinds of experiences the students had about interdisciplinary teaching and learning of mathematics and crafts. The following research questions were used:

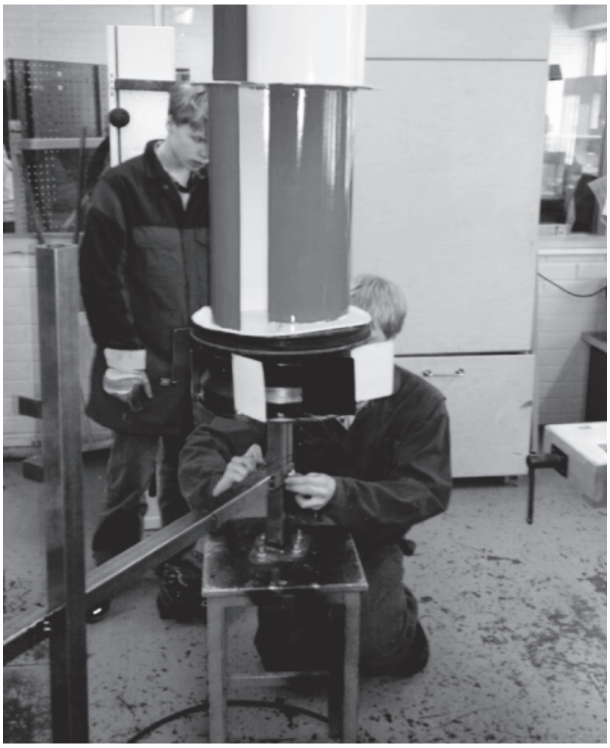

Figure 1. Wind Turbine in process

Figure 2. Hybrid pedal car in process

Figure 3. Motorised bicycle in process

1) What experiences did the students have of an interdisciplinary approach to learning mathematics through crafts?
2) What connections did they see between mathematics and crafts?

The data of this case study consists of individual interviews. After the project was finished, the researchers conducted in-depth-interviews with each student (N=17). The interview themes focused on the students' experiences of their success in the project, their learning, their work processes, and their experiences of teamwork. Furthermore the discussions focused on their background and self-evaluation in mathematics and crafts, their views of the connections between mathematics and crafts as school subjects, and general feedback on the project. The length of the interviews varied between 15–30 minutes. All the interviews were audio-recorded and transcribed for the analysis.

The analysis was based on the methods of content analysis and the interpretative approach was phenomenological (e.g. Smith et al, 2009). All three researchers took part in each step, and a common understanding of the research procedure was found to increase the reliability of the research. First, each researcher examined all the data. Then, the rough data was compiled in tables according to the above-mentioned interview themes. After that, the thematic texts were categorised according to the emerged categories which were based on the analysis tables. Finally, the categories were generalized in order to find answers to the research questions.

The data and findings were supported by observations, photos, and discussions with the students during and after the project. This was conducted by the researcher who was the mathematics teacher of the project.

Findings

Drawing on the students' interviews, the main findings of the research related to their experiences will be introduced. First, the students' affections for the collaborative project work and their views about the learning outcomes are described. Next, the descriptions of student-centeredness are examined in light of Neumann's (2013) theorization of the SCL approach. Finally, the focus is on the students' conceptions of the intersections between mathematics and crafts. The abbreviations in the quotations, such as (G2) and (B7), refer to the particular female/girl (G) or male/boy (B) student. The quotations are translated from Finnish to English.

The students' experiences of the project

Overall, the students' experiences of this kind of studying were positive, partly because the project work gave the students a much-appreciated change from the ordinary schoolwork: I*t was a nice change; we could do another, perhaps on a smaller scale*. (G4) Another student noted: *A pity this project ended. Could have made another if we had time*. (B5) However, one student also pointed out: *But still, it's good that we don't have something like this all the time*. (G3) The overall feelings presented here reveal that the students enjoyed taking part in different learning environment of mathematics but they also realised that there is still need for more ordinary teaching and learning of the subject.

On the whole, the students' motivation for project work during mathematics lessons was high: *This project has changed my attitude towards mathematics because mathematics was replaced by project work. It gives a lot of joy and is a nice way to do things together with friends*.(B5) As was noted earlier, mathematics has not proved to be a favourite subject among the school boys and girls (Jakku-Sihvonen, 2013:11–14). The way mathematics teaching was arranged in the Technical Craft environment, appeared to make mathematics a subject whose lessons were even positively anticipated, as this student reported: *In this way better: YES!!! next lesson is Mathematics*. (G5) Some students felt that it was a good idea to use mathematics lessons for this kind of project since they felt that there are plenty of mathematics lessons anyway. A common view was that there is still need for a profound teaching of various mathematics content but it is important to encourage the students to adapt mathematics in real-life problems.

Teachers' concern about the learning outcomes of their students is one reason for the doubts and hesitation concerning interdisciplinary projects; traditional subject-based teaching methods may be thought to be safer ways to reach the various learning outcomes mentioned in the curriculum. This research attempted to determine whether the students themselves felt that they had been deprived of some important aspects of mathematics in the interdisciplinary project. For example, the following student comment mentions this: *I don't feel that I have missed anything important, if, instead of the project work, we had studied, for example, equation*s.(G1) Since it was not determined what exact contents of mathematics were to be adapted, the students were asked what kind of mathematics they thought they had learned. Each team had different problems to be solved, which was reflected in the mathematics they utilised. The students in the Wind turbine team said they had needed to make a lot of measurements while the Kite team had needed to calculate the diameter. The Hybrid pedal car team had been involved with determining gears and the place of the bicycle chains. The students in the Motorised bicycle and Weather vane teams stressed the importance of overall problem solving.

When crafting their apparatus, the students needed to combine theoretical knowledge to practical craft-making processes in which craft-making skills were needed. The students had full freedom to design and make the produced artefact in a way that Pöllänen (2009:255) describes as ‘craft as design and problem-solving’. The design task was open-ended and required the students’ problem-solving in a student-centred learning environment. Drawing on the interviews, the research shows that most students seemed to be more or less satisfied with the produced artefacts: *The outcome was good...it was exciting to see the finished apparatus that we had been making for such a long time...I’m very satisfied*. (B3) Even though one team (Weather vane) did not finish their apparatus, they were happy about it: *Our project didn’t get finished, because it was quite complex...I’m still more or less satisfied*. (G4) Apparently, the outcome of the project, the self-made artefact, was important for the students. However, they seemed to appreciate the independent process of designing and making even more since they did not become discouraged even if they did not manage to get the product properly made. Also, the students appreciated the possibility to study mathematics collaboratively, instead of the more traditional individualistic learning of it, which will be discussed next.

Perceptions of collaborative learning and team work

Individual learning is still nowadays widely practiced in teaching of many subjects in Finnish education, although there is much discussion about the importance of socially-constructed knowledge. Experiments on collaborative learning and teaching in craft education have proved to be encouraging (e.g., Kangas et al, 2013). One purpose of this project was to encourage the students to work in teams and design their working collaboratively. When they were asked about their experiences of this kind of learning, it turned out that, in general, the students appreciated the social nature of the project work and emphasised the significance of fluent teamwork: *The teamwork went well; no one needed to follow [other boys’] stupid fights...my team mates were girls... some of the boys seem to disturb others every now and then*. (B1) I *consider myself to be a sociable lad... it was more pleasant to work just the two of us for such a long time... I hadn’t been able to do that alone; otherwise I had to depend on the teacher*. (B4) These experiences describe the prerequisites that are important when planning projects that rely on collaboration and team work. If teachers want to emphasise student-centeredness in students, as Neumann (2013) describes it, they need to pay careful attention to how the student teams are formed. In addition, the teams need constant support from the teacher during the whole process.

There were two teachers in the project and each of their roles was discussed in the student interviews. As described earlier in this paper, the crafts teacher provided the learning environment in the craft classroom and assisted the students in the craft-making processes. The students described his role as ”a helper (G7)”, ”a collaborator (B2)” and ”a generator of ideas (G4)” which all, bearing in mind Neumann’s (2013) perceptions about SCL, refer to the teacher’s role as a partner *with* students. On the other hand, some of the students saw the craft teacher as ”a decision-maker (G3)” or even as ”a destroyer (G6)”; the latter referred to a situation in which the crafts teacher had insisted that the student team start over designing their weather vane, but the students felt he did not give them enough support for them to do this.

Relying on Neumann’s (2013) model, the experimental project was based on SCL focusing on *in* and *with* relationships between teacher and students. The contour in was dominant during the project since the students defined their projects and thus the contents and the problems of the project were defined within the student teams. The contour with was emphasised, as during the project the mathematics teacher took part in the craft workshop and discussed the processes and problems *with* the teams. The crafts teacher organized the work and helped the teams to solve the hands-on problems that they encountered while working on their apparatus. All in all, the problems the student teams faced were handled in cooperation between the teachers and the students. There was no *on* relationship since the teachers did not define any special mathematical or craft educational context or area to be studied during the project. However, contents of both the subjects were studied and the interconnections between them will be discussed in the following.

Interconnections between Crafts and Mathematics

One of the aims of the project was to provide the students learning context in which they would figure out the connections between the school subjects. When the students were asked about the relationships they may have experienced or found out between mathematics and crafts, it was notable that the connections between crafts

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and mathematics were mostly seen from crafts to mathematics – not vice versa. Many students described what kind of mathematics is needed in crafts, but they did not see what added value crafts could bring into mathematics.

> Common to crafts and maths is calculation and measuring , and geometry... sometimes you need to think the same way; for instance, if you need to measure 26 cm and 2 mm, you measure it...and if you are making a case, you have to calculate the sides and glue them together in order to match them to be solid. (B5)

> You don't need to think so theoretically in crafts...demands mathematical thinking... geometry in maths resembles technical work. (B3)

> In crafts you need to measure and then you need maths. (G5)

We were interested to discover what the students thought they had learned during this project. One major topic that they claimed to have learned was problem solving skills in an authentic context. Some of them recognized the meaning of problem solving particularly in crafts, but also when they described the role of mathematics in crafts. One student noted, *You just can't do whatever comes to your mind in crafts either...you need maths in designing as well...*. (B3) Together with this, many of them mentioned that they had learned a new approach to thinking. One student mentioned, *This method developed a new way of thinking; I needed to think independently and I needed to learn how to apply skills and knowledge*. (B4) Interestingly, the need for deduction was seen to be common in both the subjects:

> The deduction skills are essential in both the subjects. Crafts and mathematics could be seen to be related by the need for deduction. The practice is different: mathematics is more theoretical; in crafts, you need to be able to apply what you know. (B2)

At the cognitive level, the students felt that they had learned the contents of both subjects. For example, a student commented, *In maths, I learned to think whether there was enough power if we put such-and-such size of a coil...and how much a driver could weigh so that the vehicle can move*. (B4) Similarly, another student noted, *I've [learnt] how you cannot remove the axis of a wheel...and other stuff like welding*. (B6) All this, together with notions students mentioned such as *Attitude towards mathematics has changed positively* (B1), gives an impression that the project was felt to be successful on the whole.

Discussion

At present, there is a lot of concern about how to make teaching and learning in Finnish comprehensive education more holistic, instead of continuing with the traditional subject-based arrangements. In the Finnish National Core Curriculum for Basic Education, each art subject (Music, Visual Art, Crafts (Textile and Technical), Physical Education and Home Economics) is arranged separately, as is the case with the so-called academic subjects as Mathematics, History, and language teaching. The project introduced in this paper was an attempt to combine mathematics teaching and learning with crafts.

Drawing on the student interviews after the project, it appears that their experiences were encouraging. Since the students were provided with a more authentic learning environment than they had in their traditional mathematics lessons, they needed to learn and combine their theoretical and practical knowledge and skills. In addition, they developed collaborative team working skills, and learned from each other, while the teacher assisted, encouraged and helped to find solutions.

The analysis revealed that the students' experiences of what mathematics contents they had learned varied among the student teams. On the whole, the students thought that mathematics learning had mainly focused on activities like deduction and problem solving processes which are, indeed, very important parts of mathematics (FNBE, 2004: §7.6 Mathematics). Curiously, the same contents were seen as the contents learned with craft making processes during the project.

After the project, the students' attitudes towards mathematics lessons became more positive, which was, in fact, one of the reasons for combining more popular crafts to teaching of less popular mathematics. Although this project was arranged to teach mathematics through crafts, it could have been the other way round as well, learning and teaching crafts with the help of mathematics. As can be seen, these two subjects, that seem very different at first glance, actually share many common goals and contents.

Similar experiments, with encouraging results, have been made in other countries by combining such subjects as Technology and Design with learning of Mathematics (Spendlove and Barlex, 2011; Gibson and Bell, 2011) and Science and Technology education combined with teacher education (Brears et al, 2011). Spendlove and Barlex

(2011) combined learning of Technology and Design with learning of Mathematics when they researched student teachers' attitudes towards mathematics. They state that T&D enables the meaningful real-world context for learning mathematics, which increases the students' motivation towards the subject, when they come to understand its utility and value. Gibson and Bell (2011) experimented with teaching mathematics through T&D, which provided both utility and purpose for mathematics learning. They emphasise that it is important that the teachers maintain a positive attitude towards mathematics if they teach the subject in or with a different subject area.

Moreover, integrating the teaching of STEM-subjects (Science, Technology, Engineering and Mathematics) is practised and discussed in Anglo-American contexts (Williams, 2011; Capraro et al, 2009; Spendlove and Barlex, 2011). Although STEM-education has its supporters, Williams (2011:32) is cautious about blurring these subjects, which may lead to seeing Technology education mainly as an applied field for learning the other, subjects that are conceived to be more important:

> The current state of research would seem to indicate that a STEM approach to an integrated curriculum is a flawed concept, and would have consequences for Technology Education that are undesirable. In the absence of a belief that Technology Education is a fundamental component of general education for all students, a form of STEM integration in which Technology and Engineering served to enhance the goals of Science and Mathematics may not be perceived as a bad outcome. But for those who believe in the inherent value of Technology Education, its integration with Science and Mathematics would detract from its integrity. (Williams 2011:32.)

The STEM approach contains some useful elements which could be utilised in the Finnish educational system. However, in order to allow the pupils to develop wider understanding of the world, Finnish education would benefit more from developing an interdisciplinary educational approach by integrating and promoting interaction between various other subjects as well, not only the STEM subjects. However, to reach high-level learning achievements, it is necessary that interdisciplinary teaching and learning is based on a solid background knowledge of different subjects.

Before making more profound conclusions, we must bear in mind the small scale of the project presented in this article. Without doubt, there is a need for further studies and experiments on interdisciplinary learning and teaching in order to develop appropriate pedagogy. All interaction and integration demands much subject-based and pedagogical knowledge and cooperation skills from the teachers. The news about the curriculum refinement process going on in Finland (FNBE, 2014) at the time of writing this article, has shown that a holistic approach to teaching and learning will be emphasised in Finnish comprehensive education. For interdisciplinary education to be developed further, support is needed for the teachers to collaborate and learn new teaching approaches. This is one of the challenges and pre-requisites for the practice of interdisciplinary teaching to become more common in the future.

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