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Students' conceptions of learning and learning outcomes in Technology Education

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Abstract

This study sought to explore students' conceptions of learning and learning outcomes in Technology Education. The background variables facilitated a comparison of the students who had experienced more Learner-Centred or Teacher-Directed Learning Approaches and those who had experienced more Technical or Textile Work.The results reveal that the learning conceptions of students who had experienced more Learner-Centred Learning were significantly more positive, with higher levels of learning outcomes, than those of students who had experienced more Teacher-Directed Learning. The conceptions of learning outcomes in the Technical Approach were also more positive than those in the Textile Approach. The main development targets reflected the students' weak conceptions of Teacher-Directed Learning and different conceptions of either Technical or Textile Approach learning outcomes. Teacher-Directed learning orientations should be developed more deeply and united with the Techno-Scientific phenomena of natural and engineering sciences.

Keywords: Learner-Centred Learning, Teacher-Directed Learning, Technical and Textile Work Approach, Learning Outcomes

Introduction

Technology education (TE) is taught within the Craft subject in Finland (The National Core Curriculum for Basic Education, 2014). Uno Cygnaeus, the original creator of the Craft subject in 1866, first called it *Sloyd* (Kantola, Nikkanen, Kari, & Kananoja, 1999; see also Whittaker, 2014, pp. 83–104). Since then, *Sloyd* has transitioned from being a part of folk culture to being a part of school culture and, finally, into a science within the Teacher Education of TE in Finland (Faculty of Education, 1997; Metsärinne, 2008; Peltonen, 1999).

TE is located at the intersection of Human Sciences, Engineering, Arts and Natural Sciences. (Peltonen, 1993). In previous studies, Human Sciences and Engineering and, similarly, science knowledge and artwork have been placed in opposition (Autio, 1997; Metsärinne, 2003; Peltonen, 2001; Syrjäläinen, 2003). However, these are not true opposites; instead, they are associates, since Engineering can be used to apply Natural Sciences to the use of new technologies and Art can be used to interpret the reality and experiences of nature.

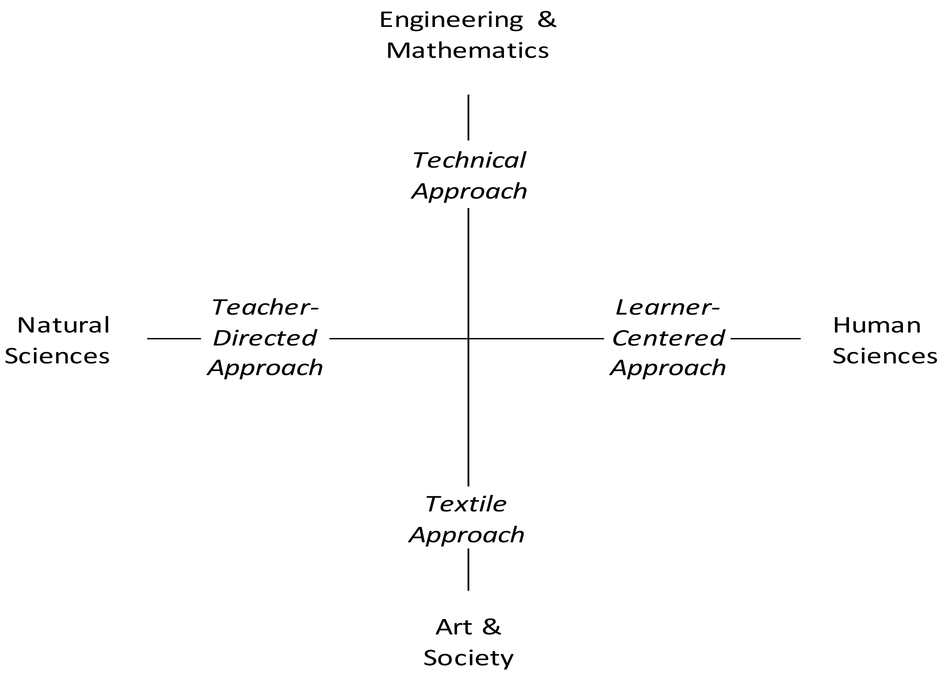

Figure 1. Research design in the framework of Technology Education

Perhaps the most fundamental division in scientific worldviews exists between the phenomenology of the Human Sciences, which represents the learner's life-world, and the positivism of the Natural Sciences. The horizontal axis in Figure 1 represents the relationship between humans and nature, in which technologies are a mediating factor for humans to understand and produce (cf. Ihde, 1998). Together, humans and nature can even represent a completely constructed technological worldview (cf. Dakers, 2011). The second division exists between the approaches of the mathematically oriented Engineering and the socially shared Arts.

As de Vries (2011) stated, "Engineering is [more] a combination of intervention in reality and the scientific study of than intervention" and "this makes Engineering 'a' science, next to natural and human/social sciences" (p. 3). Art reveals the activity of the maker in the process of creation; expressing is something that the maker does (Hospers, 1955). Art and Engineering are needed in many aspects of design-oriented thinking processes (Benson & Trevelen, 2011). Their similarities date back to the Renaissance era, during which the technical world was seen as arts or technics (Airaksinen, 2003).

The pedagogical approaches on the horizontal axis are learner-centred learning (Learner-Centred Approach) and the teacher-directed learning approach (Teacher-Directed Approach). Students' readiness for self-regulation and technological competence is the core of both pedagogical approaches (c.f. Dewey, 2011; ITEA, 2000/2007; Kallio, 2014). In general, learning approaches emphasize either the Humanities or the Natural Sciences. The Humanistic perspective emphasizes the Learner-Centred Approach, and the Natural Sciences perspective emphasizes the Teacher-Directed Approach. These two approaches are associated with developing either learners' intrinsic needs or teachers' learning orientations towards students' production of creating and learning.

The pedagogical approaches on the vertical axis are the technical work learning approach (Technical Approach) and the textile learning approach (Textile Approach). In Finnish schools, the technical approach comprises, for example, machinery, embedded electrical systems, technical design and different materials, such as metal, plastics and wood. The textile approach comprises, for example, clothing, decorating, aesthetic design and the use of fabrics. Knowledge of Engineering is applied more in the Technical Approach, while knowledge of socially shared Art is applied more in the Textile Approach (Autio, 1997; Metsärinne, 2003; Peltonen, 2001; Syrjäläinen, 2003). These two approaches are associated with how to develop technological learning content and outcomes without dichotomous thinking.

This study focuses on the students who have experienced either the Technical or Textile Approach more than average and on the students who have experienced either the Teacher-Directed or the Learner-Centred Approach more than average. The research task within the developing subject is What are students' conceptions of the two general learning approaches and the two technological learning approaches?

Pedagogical Approaches

Learner-Centred and Teacher-Directed Approach

The Learner-Centred Approach highlights students' ability to improve their life realities through technological projects. This is based on learners' life-worlds and represents a humanistic world-view. Unlike the Standards-Referenced Assessment, student production and learning require teachers to adjust their own professional knowledge and expertise to arrive at learners' levels of quality judgment for grading decisions (cf. Klenowski & Wyatt-Smith, 2014). Students' social interactions are involved in project creation; however, the common ideas that are explored through experiments for individual learning activities are not the same as a socio-cultural perspective, in which interactions with others involve the development of a common frame of mind (Banks, 2009, p. 377). In Learner-Centred Learning, learners define their own goals for learning and production activities. Ideation, product planning and product construction are based on these goals. When assessing the processes of product ideation, planning, construction and testing, assessment focuses on predefined goals on which the implementation of technological activities is based (Kallio & Metsärinne, 2015).

The Teacher-Directed approach emphasizes students' scientific learning abilities to extend their conceptual and theoretical world-views and their technological abilities to create innovations by using and managing technology. The Teacher-Directed Approach leads to the demonstration of proven scientific knowledge via common technological solutions. For example, such an approach might be used when assignments, ideas and product sketches are introduced to the learner before he/she begins to outline his/her own project (cf. Blomdahl & Rogala, 2008). In this kind of learning, the student needs to acquire more scientific knowledge and gain familiarity with a range of technologies. He must also develop an understanding of the methods and language of science and technology and their interactions with society and environment. The tasks are designed to engage students' learning in scientific inquiry and problem-solving and to develop their confidence and competence in tackling a wide range of real world technological tasks and problems (Hodson, 2009). The objective rarely accurately follows the model of technologies.

Technical and Textile Approach

Technical and Textile Work were separate school subjects until 1998. After that, they were sub-areas of a single subject: Craft. In the newest national core curriculum (2014), they are only approaches, and the types of methods are not clearly mentioned. Some municipalities teach both sub-areas by dividing classroom time evenly. Both sub-areas are usually studied together only in grades 3 and 4; after that, students specialize in one sub-area. This specialization continues until the end of comprehensive school. Craft is compulsory until the seventh grade. In the eighth and ninth grades, it becomes optional, and students learn through a more Learner-Centred Approach. Usually, educational equality means that students can emphasize either the technical or the textile approach; however, sometimes, educational equality means that lessons are divided equally between the approaches. Any technologies used are not listed in the National Core Curriculums for Basic Education (1994, 2004, 2014); instead, teachers make the decisions at the municipal and local levels. However, though Finnish learning objectives are quite similar to those in other countries (cf. Rasinen, 2003), learning outcomes are still divided among traditions. The newest national core curriculum (2014) noted that 'the subject is multi-material'. This multi-materialism is associated with students' ability to extend their technological worldviews by using and managing all kinds of materials and technologies across different contexts and actions.

Methods

Research questions

1) What kinds of technological learning outcomes and conceptions do students have when they experience the Learner-Centred or Teacher-Directed Approach?
2) What kinds of technological learning outcomes and conceptions do students have when they experience the Technical or Textile Approaches?

Measures and participants

The data from the Finnish National Board of Education assessment was collected by stratified sampling from 152 compulsory education schools representing a comprehensive cross-section of counties and groups of districts. The assessment consisted of two samples: a general sample (N = 4,792) of 152 schools, and a narrow sample (n = 1,548) of 49 of the 152 schools. All of the participating students were in the ninth grade (Laitinen, Hilmola & Juntunen, 2011). The assessment consisted of three sets of questionnaires including variables for technological learning outcomes, learning conceptions and learning approaches. The participants of the narrowed sample answered all questionnaires, and therefore it was used in this study.

The questionnaire of learning approaches comprised 23 questions of students' experiences of either the Learner-Centred or the Teacher-Directed Approach and the Technical or the Textile Approach.

The questionnaire of technological learning outcomes comprised 17 questions related to the Technical Approach and 17 questions related to the Textile Approach. The learning outcomes questionnaire was constructed using the most common and important learning contents of the Technical and Textile approaches, as identified by a group of experts and subject teachers. Specifically, the questionnaire comprised questions on Tools and Materials, Construction and Methods, Technological Literacy, Product Planning, Safety Awareness and Sustainability (Metsärinne, 2011; Metsärinne, Kallio & Virta, 2014).

The learning conceptions questionnaire comprised attitudes (e.g. liking, experiencing and self-concept), self-directiveness, skillfulness and meaningfullness of learning. Self-directiveness refers to an individual's ability to manage his/her own learning by developing processes and addressing personal learning outcomes (Hays, 2009). Skillfulness allows individuals' abilities to reach a high enough level to apply their skills to technological projects. Meaningfulness requires all information learned within a project to be learnt as a whole, instead of through individual components. According to Bloom (1976), an attitude is a permanent quality. It is difficult to change during a short learning period and often manifests through three aspects of learning in educational research: affective (feeling), cognitive (knowing) and conative (doing).

The attitude questionnaire was a shortened and modified Fennema and Sherman (1976) test, which was originally developed for measuring attitudes in Mathematics. Instead of using their original version, which contained nine factors, this questionnaire contained three factors with five statements each (cf. Metsämuuronen, 2012; Sachs & Leung, 2007). This is the same method as used in the PISA (Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) measurements. The shortened test described has been used in numerous assessment questionnaires in several subjects (e.g. Mathematics, Mother Tongue, Science, Languages, Art and Physical Education) throughout different grades in Finland (Metsämuuronen, p. 13). The three factor names were Liking the school subject, Self-concept in the subject, and Experiencing utility in the subject (Metsämuuronen). Earlier research (Metsärinne & Kallio, 2016) has found, through analyses of students' learning outcomes, that *utility* is a cognitive attitude factor related to a learner's knowledge, opinions and beliefs regarding a forthcoming production entity; the affective factor *liking* comprises emotions, feelings and assessments of forthcoming production; and 3) *self-concept* is a behavioural factor comprising intended methods of forthcoming production.

Procedure

The procedure followed three steps. First, the sub-samples of the technological learning outcomes were formed. Next, the internal consistencies of the learning conception questionnaires were calculated. Finally, the results were calculated using cross-tabulation and correlation matrixes.

First step: Formulation of the sub-samples

First, four sub-samples were formed of students who stated that they had experienced 'a lot' of either the Learner-Centred or the Teacher-Directed Approach and the Technical or the Textile Approach. In this step, the structure and the internal consistency of the learning approaches were explored.

Table 1. Exploratory factor analysis of the learning approaches.

Technological Learning Outcomes Questionnaire								
	Description				Factor structure matrix			
	M	SD	Skew-ness	Kurto-sis	Textile Approach	Learner-Centred Approach	Technical Approach	Teacher-Directed Approach
Knitting	2.74	1.25	.07	-1.05	**.885**	.202	-.293	.187
Sewing clothes	2.96	1.24	-.10	-1.01	**.873**	.232	-.293	.177
Crocheting	2.85	1.20	-.02	-.97	**.857**	.194	-.247	.189
Reading of textile diagrams	2.70	1.22	.08	-1.02	**.813**	.289	-.196	.207
Clothing care and repairs	2.66	1.18	.15	-.86	**.789**	.209	-.190	.188
Safety of textile technology	2.80	1.22	.05	-.93	**.789**	.215	-.173	.210

Composing textile diagrams	2.48	1.21	.30	-.92	**.756**	.304	-.116	.157
Own product planning	3.09	1.17	-.19	-.71	.259	**.919**	.224	.335
Manufacturing based on own planning	3.18	1.17	-.31	-.63	.213	**.867**	.238	.347
Presenting own planning to teacher	3.13	1.26	-.24	-.90	.192	**.860**	.242	.324
Own ideating of new products	3.23	1.17	-.30	-.61	.288	**.858**	.179	.367
Evaluating own manufacturing process	2.86	1.19	-.05	-.85	.315	**.696**	.205	.384
Metal techniques	2.76	1.27	.05	-1.09	-.347	.151	**.898**	.145
Wood techniques	3.24	1.07	-.26	-.47	-.243	.196	**.805**	.252
Electronics	2.56	1.27	.22	-1.10	-.258	.187	**.798**	.136
Composing technical drawings	2.45	1.20	.27	-.96	-.111	.358	**.697**	.188
Reading of technical drawings	2.54	1.16	.20	-.88	-.071	.355	**.676**	.221
Safety of technical technology	3.56	1.12	-.58	-.26	-.136	.176	**.663**	.267
Machinery	1.80	1.13	1.31	.73	-.106	.140	**.565**	.069
Manufacturing products planned by teacher	3.18	1.13	-.27	-.55	.096	.281	.245	**.760**
Manufacturing products by following teacher’s guidance	3.51	1.03	-.53	-.08	.244	.320	.115	**.750**
Copying products	3.08	1.10	-.23	-.51	.195	.296	.220	**.739**
Receiving product ideas from teacher	3.09	1.09	-.30	-.51	.208	.516	.265	**.662**

Extraction Method: maximum likelihood.
Rotation Method: oblimin with kaiser normalization.

The factor structure was clear, such that all factors were formed without difficulties and all statements were rated meaningfully (see Little, Lindenberger, & Nesselroade, 1999). The internal consistency was evaluated by calculating Cronbach’s (1951) alphas for the entire questionnaire (alpha = .90) and for each factor (alpha = .92 for the Textile Approach factor; alpha = .90 for the Learner-Centred Approach factor; alpha = .89 for the Technical Approach factor; alpha = .82 for the Teacher-Directed Approach factor). These alpha values can be considered high for all factors (Gliner, Morgan, & Harmon, 2001).

The students who responded with a 4 or a 5 on the five-point scale were included in each sub-sample as follows:

- sub-sample for the Teacher-Directed Approach: n = 425,
- sub-sample for the Student-Centred Approach: n = 359,
- sub-sample for the Technical Approach: n = 186 and
- sub-sample for the Textile Approach n = 263.

Second step: Internal consistency of the learning conceptions questionnaire

The internal consistencies of the learning conception factors were confirmed by calculating Cronbach’s (1951) alphas separately for each sub-sample (see Table 2).

Table 2. Internal consistency of the learning conceptions.

Learning Conceptions Questionaires				
	Cronbach's alphas			
	Approaches			
Factor	Teacher-Directed (n = 425)	Learner-Centered (n = 359)	Technical (n = 186)	Textile (n = 263)
Liking	.89	.86	.88	.88
Experiencing utility	.82	.82	.87	.77
Self-concept	.71	.70	.62	.72
Skillfulness	.75	.70	.82	.83
Self-directiveness	.81	.79	.86	.83
Meaningfulness	.88	.86	.90	.87

Number of items in all factors = 5

The alpha values can be considered high for all factors (Gliner, Morgan, & Harmon, 2001).

Third step: Cross-tabulation and correlation matrices

After the sub-samples were formed and the internal consistencies of the learning conception questionnaire were explored, the results were formed according to the research questions. The differences in learning outcomes and conceptions between students who had experienced the Technical and Textile approaches and the Learner-Centred and Teacher-Directed Approaches were analyzed using cross-tabulation and correlation matrices.

Results

Question 1: Teacher-Directed and Student-Centred Approach

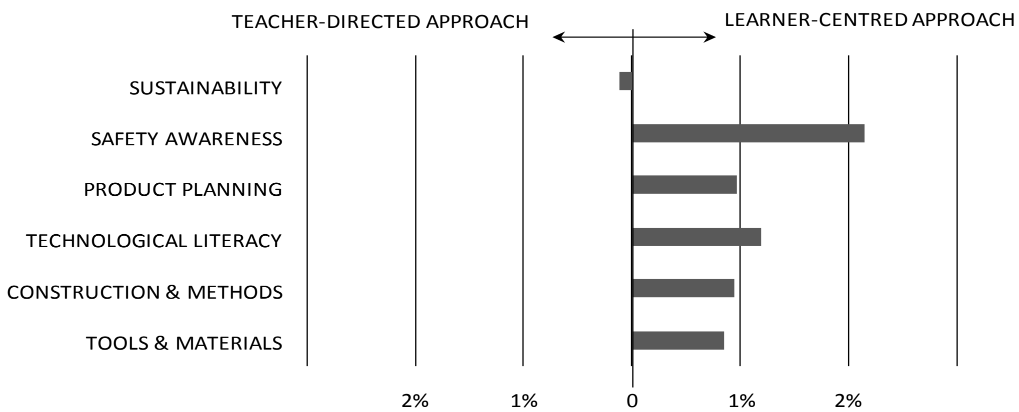

Figure 2. Differences in learning outcomes for content areas (absolute scale indicating percentage points).

Students who had experienced the Learner-Centred Approach exhibited systematically better learning outcomes in all measured contents. Students who had experienced the Teacher-Directed Approach had better results in 'sustainability' only.

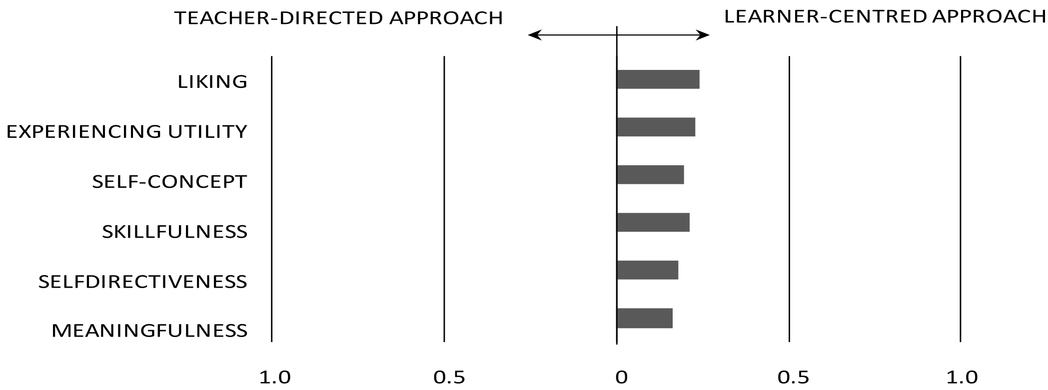

Figure 3. Differences in conceptions of learning (original five-point scale is converted from 1 to 5 to -2.5 to +2.5).

Students who had experienced the Learner-Centred Approach had more positive conceptions of learning.

Table 3. Correlations between learning outcomes and conceptions of learning.

Learner-Centred and Teacher-Directed Approaches						
	Experiencing Utility	Liking	Self-concept	Meaning-fulness	Self-directive-ness	Skillful-ness
Tools & materials			.04		.13	
Construction & methods	.13		.04	.10	.14	
Technological literacy	.10	.05	.01	.08	.00	
Product planning	.02					.03
Safety awareness	.09	.20	.05	.13	.12	
Sustainability						

The correlations of the learner-centred approach are on a white background and the correlations of the teacher-directed approach are on a grey background.

Non-significant correlations have been removed, p > .05.

Learning outcomes and conceptions of learning were correlated more among those students who had experienced the Learner-Centred Approach. Technological Literacy and Safety Awareness were correlated with conceptions of learning among those students who had experienced Learner-Centred Learning. The highest correlation was found within the Learner-Centred Approach between Safety Awareness and Liking. Interestingly, Safety Awareness was more correlated with *self-directiveness* within the Teacher-Directed Approach. Finally, Construction & Methods was more correlated with conceptions of learning within Teacher-Directed Learning.

Question 2: Textile and Technical Approach

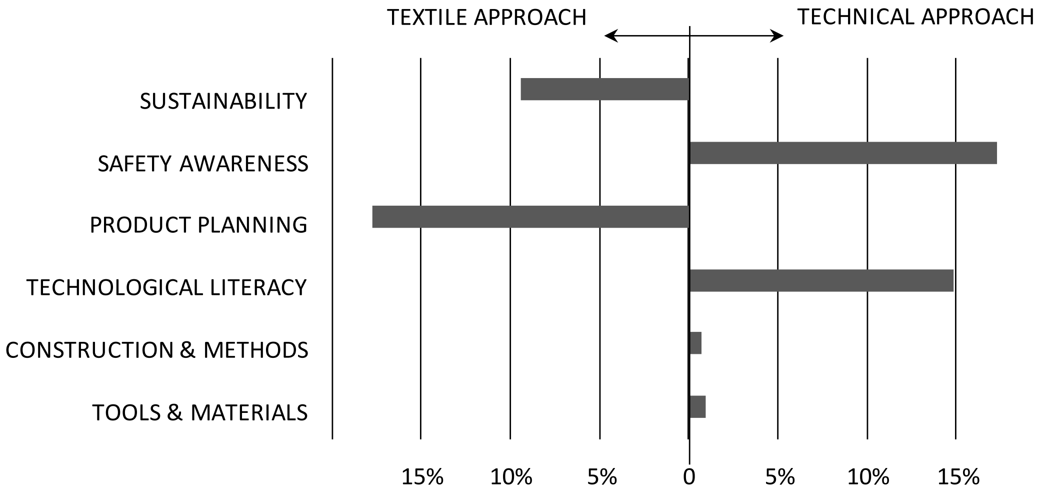

Figure 4. Differences in learning outcomes (absolute scale indicating percentage points).

The differences between the Textile and Technical approaches were bigger than those between Learner-Centred and Teacher-Directed Learning (cf. Figure 3). Students who had experienced the Textile approach were more successful in both Product Planning and Sustainability. Students who had experienced the Technical Approach were better at Safety Awareness, Technological Literacy and (to a lesser degree) Construction & Methods and Tools & Materials.

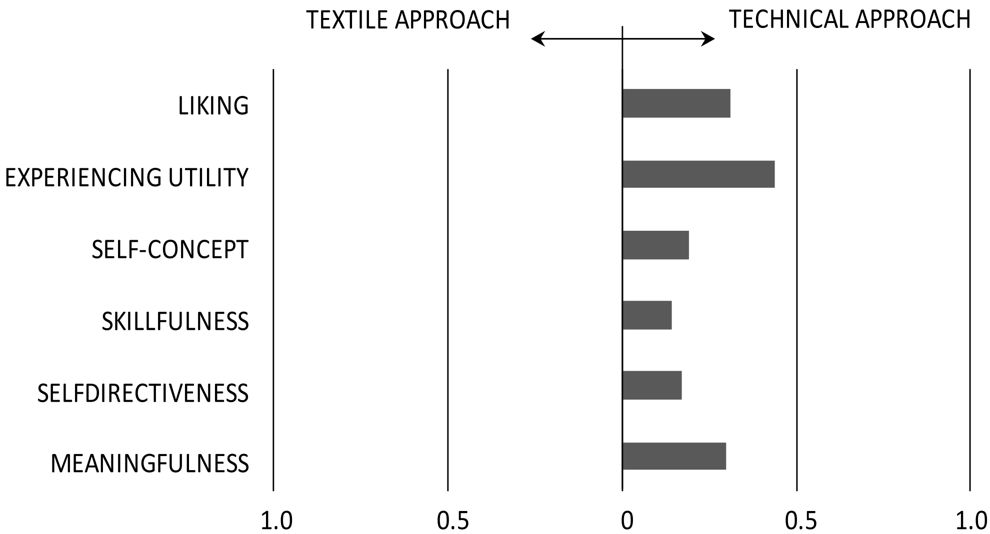

Figure 5. Differences in conceptions of learning (original five-point scale converted from 1 to 5 to -2.5 to +2.5).

Students who had experienced the Technical approach had more positive conceptions of both the subject and themselves as learners than those who had experienced the Textile approach. The most positive conceptions were associated with 'experiencing utility'.

Table 4. The correlations between learning outcomes and conceptions.

Technical and Textile Approaches						
	Experiencing Utility	Liking	Self-concept	Meaning-fulness	Self-directive-ness	Skill-fulness
Tools & materials		.14	.02	.01	.01	.17
Construction & methods	.15	.18	.19	.08	.17	.19
Technological literacy	.21	.06	.18	.06	.21	
Product planning		.21	.22	.18	.16	.17
Safety awareness	.21		.21	.20	.21	
Sustainability	.17				.16	

The correlations of the technical approach are on a white background,
And the correlations of the textile approach are on a grey background.
Non-significant correlations have been removed, $p > .05$

The cross-tabulation of learning outcomes and conceptions indicates results similar to those shown in Figure 5. The Product Planning statements are correlated with the Textile Approach. Construction & Methods, Technological Literacy, Safety Awareness, and Experiencing Utility are all correlated with the Technical Approach.

Conclusions

The Teacher-Directed and Learner-Centred Approaches are associated with the type of phenomenon-based learning task TE should employ and how this affects students' learning outcomes. In the Learner-Centred Approach, a learner's inner need to envision and implement technological projects forms a phenomenon-inspired learning task. By contrast, in the Teacher-Directed Approach, the phenomenon decided by the teacher, often representing a certain knowledge of Natural Science, forms the learning task. The conceptions of the students who had experienced the Learner-Centred Approach were significantly more positive than those of the students who had experienced the Teacher-Directed Approach. Their learning outcomes were also greater. This suggests that the Learner-Centred Approach should be favoured over the Teacher-Directed Approach.

It is important to consider teachers' phenomenon-based learning tasks, since these might focus on producing results through measured technological learning outcomes. Such tasks might also be too separate from students' life-worlds. Therefore, it is important to examine how other subjects, such as STEAM subjects (science, technology, engineering, arts and mathematics), could be linked meaningfully in phenomenon-based technological learning. According to Barlex (2011, p. 120), TE "will have to demonstrate the effective use of science and mathematics in the teaching and learning so that pupils experience the utility of these subjects." Furthermore, according to Williams (2011), Engineering Education is a promising foundation for TE development, especially in the upper levels of compulsory education. Thus far, the subject's development has followed a different direction from traditional teacher education in Finland, which specialized in technical work. It has been necessary to reduce some engineering content, while giving higher priority to product planning and textile material learning and making. According to this study's results, students require more in-depth teaching in product planning in technical work to achieve more positive results. However, technical work often requires more different kinds of product planning methods than textile work. Students have to understand more technological functions before they begin product planning. In general, technological system planning and their innovations can be specialized in-depth, where learning needs are more frequently addressed through Teacher-Directed Approaches at the school level of TE.

The results of this study show that the Teacher-Directed Approach illustrates the phenomenon of science knowledge, while the Learner-Centred Approach is related to the phenomenon of learners' life-worlds. The results also illustrate the division between the Technical and Textile Approaches. The goals of learning and technological activities should not be based on specific predefined Technical or Textile Work traditions; instead, the learning contents should be reformulated. In summary, the students' conceptions of the Learner-Centred Approach and Learning Outcomes were good. Therefore, it is important to develop ways for Techno-Scientifically and Teacher-Directed learning orientations to create more positive experiences for students' technological learning.

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References

Airaksinen, T. (2003). *Tekniikan suuret kertomukset. Filosofinen raportti.* Helsinki, Finland: Otava.

Autio, O. (1997). *Oppilaiden teknisten valmiuksien kehittyminen peruskoulussa. Tytöt ja pojat samansisältöisen käsityöopetuksen kokeilussa*. Helsinki, Finland: University of Helsinki. Helsingin yliopiston opettajankoulutuslaitos. Tutkimuksia 177.

Banks, F. (2009). Research of teaching and learning in technology education. In A. Jones & M. de Vries, (Eds.), International handbook of research and development in technology education. *International technology education series* (pp. 373–390). Rotterdam, The Netherlands: Sense.

Barlex, D. (2011). Achieving creativity in the technology classroom: The English experience in secondary schools. In M. Barak & M. Hacker (Eds), *Fostering human development through engineering and technology education. International Technology Education Series* (pp. 103–130). Rotterdam, The Netherlands: Sense.

Benson, C. & Treleven, T. (2011). Designerly thinking in the foundation stage. In C. Benson and J. Lunt (Eds.), International handbook of primary technology education: Reviewing the past twenty years. *International Technology Education Series* (pp. 137–150). Rotterdam, The Netherlands: Sense.

Blomdahl, E. & Rogala, W. (2008). Technology in compulsory school: Why? What? How? *Design and Technology Education: An International Journal, 13*(1), 19–28.

Bloom, B. (1976) *Human characteristics and school learning.* New York, NY: McGraw-Hill.

Cronbach, L. (1951) Coefficient alpha and the internal structure of tests, *Psychometrika, 16,* 297–334.

Dakers, J. R. (2011). Blurring the boundaries between human and world. In M. J. de Vries (Ed.), *Positioning technology education in the curriculum*: *International technology education series* (pp. 41–52). Rotterdam, The Netherlands: Sense.
Dewey, J. (2011). *Demokratia ja kasvatus*. [*Democracy and education: An introduction to the philosophy of education*, 1916]. Tampere, Finland: Eurooppalaisen filosofian seura.
Faculty of Education. (1997). 1996/1997, 1997/98. *ECTS European credit transfer system. course catalogue.* Turku, Finland: University of Turku.
Fennema, E. & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitudes Scales: Instruments designed to measure attitudes toward the learning of mathematics by males and females, *Journal for Research in Mathematics Education, 7,* 324–326.
Finnish National Board of Education (1994). *National Core Curriculum for Basic Education.* Helsinki, Finland: Author.
Finnish National Board of Education (2004). *National Core Curriculum for Basic Education.* Helsinki, Finland: Author.
Finnish National Board of Education (2014). *National Core Curriculum for Basic Education* Helsinki, Finland: Author.
Gliner, J., Morgan, G. & Harmon, R. (2001). Measurement reliability, *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(4), 486–88.
Hays, R. (2009). Adult self-directed learning: Setting your own agenda. *InnovAiT*,.7, 434–438.
Hodson, D. (2009). *Teaching and learning about science: Language, theories, methods, history, traditions and values.* Rotterdam, The Netherlands: Sense.
Hospers, J. (1954). XIV.- The concepts of artistic expression. *Proceedings of the Aristotelia Society*, 55, new series, 313-344.
Ihde, D. (1998). *Expanding hermeneutics: Visualism in science*. Evanston, IL: Northwestern University Press in Phenomenology & Existential Philosophy.
ITEA. International technology education association. (2000/2007). *Standard for technological literacy: Content for the study of technology*. Reston, VA: Author.
Kallio, M. (2014). *Risk-responsibility in safety education culture.* Turku, Finland: University of Turku. Annales Universitatis Turkuensis C382.
Kallio, M. & Metsärinne, M. (2015). How do different background variables predict learning outcomes? *International Journal of Technology and Design Education*. doi:10.1007/s10798-015-9339-7
Kantola, J., Nikkanen, P., Kari, J. & Kananoja, T. (1999). *Through education into the world of work: Uno Cygnaeus, the father of technology education.* Jyväskylä, Finland: Institution for Educational Research, University of Jyväskylä.
Klenowski, V. & Wyatt-Smith, C. (2014). *Assessment for education: Standards, judgement and moderation. Los Angeles, CA:* Sage.
Laitinen, S., Hilmola A. & Juntunen, M.-L. (2011). *Perusopetuksen musiikin, kuvataiteen ja käsityön oppimistulosten arviointi 9. vuosiluokalla [Assessment of learning results in compulsory education music, art and craft in 9th grade].* Helsinki, Finland: Training Reports 2011:1; Finnish National Board of Education.
Little, T. D., Lindenberger, U., & Nesselroade, J. R. (1999) On selecting indicators for multivariate measurement and modeling with latent variables: When "good" indicators are bad and "bad" indicators are good, *Psychological Methods, 4*(2), 192–211.
Metsämuuronen, J. (2012). Challenges of the Fennema-Sherman Test in the international comparisons, *International Journal of Psychological Studies*, *4*(3), 1–22.
Metsärinne, M. (2003). *Teknisen käsityön visio-opetus ja -oppiminen. Toiminta- ja tapaustutkimus peruskoulun 9. luokalla. [Sloyd Vision Teaching and Learning. Case and Action Research in 9th Grade].* Annales Universitatis Turkuensis, C 198. Turku, Finland: University of Turku.

Metsärinne, M. (2008). Suomen koulukäsityön neljä aikakautta opetussuunnitelmien ja teknisen työn oppikirjojen kuvauksena - kohti monipuolista koulukäsityön tutkimusta ja käytänteitä [The four school Sloyd periods in Finland by description of curriculums and technical work schoolbooks: Towards multilateral school Sloyd research and practice].*Techne Series. Research in Sloyd Education and Craft Science* A, 13, 1–128.

Metsärinne, M. (2011). Käsityön prosessioppimisen tarkastelua koulukäsityön perus- ja otosmittariarvioinnin perusteella [Examining process learning of technology by basic and sample assessment], in: S. Laitinen & A. Hilmola (Eds.), *Taito- ja taideaineiden oppimistulokset – asiantuntijoiden arviointia [Learning results in craft: An expert analysis]* (pp. 194-206). Helsinki, Finland: Reports 2011:11; Finnish National Board of Education.

Metsärinne, M., Kallio, M., & Virta. K. (2014). Pupils' readiness for self-regulated learning in the forethought phase of exploratory production. *International Journal of Technology and Design Education, 25*(1), 85–108.

Metsärinne, M., & Kallio, M. (2016). How are students' attitudes related to Sloyd learning outcomes? *International Journal of Technology and Design Education 26*(3), 353–371.

Peltonen, J. (1993). Outlines on research on craft education. *Kasvatus 24*(1), 6–11Peltonen, J. (1999). Slöjdkultur och slöjdpedagogik. En vetenskapsteoretisk betraktelse. [Sloyd culture and Sloyd education in the light of the theory of science] *Nordisk Pedagogik Journal of Nordic Educational Research, 19*(2), 67-77.

Peltonen, J. (2001). Utbildning för akademiskt innehållsproduktion inom slöjdpedagogik. In C. Nygren-Landgärds & J. Peltonen (Eds.), Visioner om slöjd och slöjdpedagogik. Visions on Sloyd and Sloyd Education. *Techne Series. Research in Sloyd education and craft science* B:10, 331–342.

Rasinen, A. (2003). An analysis of the technology education curriculum of six countries. *Journal of Technology Education, 15*(1), 31–47.

Sachs, J. & Leung, S. O. (2007). Shortened versions of Fennema-Sherman mathematic attitude scales employing trace information, *Psychologika, 50*,(3), 224–235.

Syrjäläinen, E. (2003). *Käsityön opettajan pedagogisen tiedon lähteellä: Persoonalliset toimintatavat ja periaatteet käsityön opetuksen kontekstissa. [At the source of craft teachers' pedagogical knowledge: Personal procedures and principles in craft teaching context]*. Helsinki, Finland: Publication 12 of Department of Home Economics and Craft Science.

Vries, M. J. de (2011). Introduction. In M. J. de Vries (Ed.) *Positioning technology education in the curriculum: International Technology Education Series,* (pp. 1-7). Rotterdam, The Netherlands: Sense.

Whittaker, D. J. (2014). *The impact and legacy of educational Sloyd: Head and hands in harness.* New York, NY: Routledge, Taylor & Francis Group.

Williams, P. J. (2011). Engineering: Good for technology education. In M. J. de Vries (Ed.), *Position technology education in the curriculum*: *International Technology Education Series* (pp. 87–100). Rotterdam, The Netherlands: Sense.