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Technology education goal defining framework

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Abstract

The purpose of this article is to develop theoretical framework for defining technology education (TE) goals. First, approaches to technocratic determinism, the determinism of nature, voluntarism and aestheticism of technology have been considered within the same framework. Second, four alternative definitions for technology (Freenberg, 2007) have been applied within these approaches. Instrumentalism emphasises learners' creative product production. The critical theory of technology emphasises cultural impact of learners' product using and learning design knowledge. Determinism emphasises learner technology understanding and substantivism learner technology appraising. Third, analysing by the approaches, a sample of the TE goals of Finnish craft student teachers (n=100) wanted to develop for junior- and high school teaching and learning is described. The goals and the corresponding learning materials showed that they were evenly distributed across all the approaches. The framework provides comprehensive thinking ways for defining TE goals and curriculum.

Keywords

Technology education goal; technology education approach; alternative definitions for technology

Introduction

The purpose of this article is to develop a technology education (TE) goal defining a framework based on a TE science network (Metsärinne & Kallio, 2016, 2017; Metsärinne 2021). The technology education science network (TESN) consists of technical, natural and human sciences and aesthetics in cultures of technology. Mathematics is particularly related to the natura and technical sciences in the framework. Together these disciplines form the creative components of our culture (Bunge, 2003).

The TESN has been used to introduce the research design for exploring students' conceptions of learning and learning outcomes in TE (see Metsärinne & Kallio, 2016). After that, the framework was further developed to describe the learning and teaching areas between the four main sciences (see Metsärinne & Kallio, 2017). Based on these, the priority areas of Finnish craft subject teacher education and the basic dimensions of school craft design and make were described (see Metsärinne, 2021).

According to Parikka and Rasinen (1994), technology must be defined from an educational approach for school TE. That has been the focus in Finnish craft education i.e., TE. However, no one discipline unites all technologies (Mitcham, 1994) and nobody would be able to grasp all the technologies and so specialisation is unavoidable (Ropohl, 1997; Peltonen, 2009). Specialisation is aimed to develop the TESN based approaches with Freenberg's (2007) four approaches of alternative definitions for technology for the purpose of this study.

Theoretical framework

TESN and the alternative definitions for technology-based approaches are at the end of the axes. The so-called extreme approaches of this network marked in black are combined with the approaches of Freenberg's (2007) technology in brackets. They and Freenberg's alternative definitions for technology between them form the theoretical framework for defining TE goals.

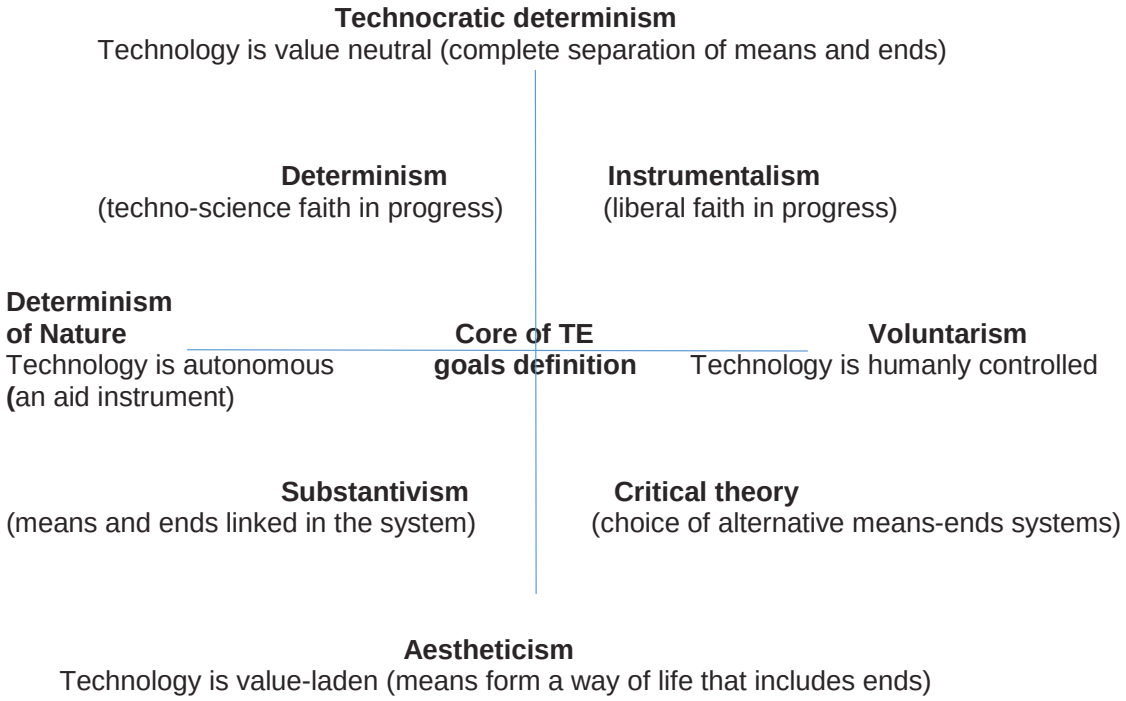

Figure 1. Technology education goal defining framework applied from the TESN (Metsärinne & Kallio 2017, Metsärinne 2021) and Alternative definition for technology (Freenberg 2007).

TE goal defining approaches

Voluntarism is a perception that technical change does not follow its own internal laws, but it is based on human discretion that a person can resolve according to their own needs and values (Parikka et al., 2011) Voluntarism relates to learner life situations, actions and thoughts in TE. The learner serves as a basis for dealing with the voluntarism and they can affect the development of technology.

When the TE goal defining are based on a learners' subjective value choices of action or production goals, it is a matter of voluntaristic decisionism (Parikka et al., 2011). It is a belief in the opportunities for a learner to influence the technological development by outlining their own personal learning goals for own production or other technological operation. This is not related to arbitrary or technology

decision-makers' power lines for the goal defining, which refer to other definitions of voluntaristic decisionism (Niiniluoto, 2020).

When a learner defines conditions for diversifying the school trip instead of walking, then the goals of the product are not necessarily the most important factor for defining the goal. Learners must derive the goals for the product primarily from the conditions and criteria of the school trip. They select and develop knowledge of technology in product planning and construction under the defined goals and criteria. According to the criteria, learners test the self-made product and collect qualitative and/or quantitative information. These exploratory production learning principles of the TE method coincide with the main principles of voluntarism (Metsärinne & Kallio, 2011).

If a student believes that experts are sure about the correct choices and have the correct answers, it is referred to as value-objective voluntarism (Parikka et al., 2011). When learners have realised technological development through the decisions and actions of engineers, the experts' certain social situations and field of engineering work are determined. Learners' reflections on how these values relate to the growth of a learner's own learning may remain detached. The situation can be similar if the learner defines the goals according to some technological work of a particular artist and by interpreting its features. In this case more emphasis is likely to be placed on the appearance of the product than on its technical design.

Determinism of nature consists of the laws of the natural sciences which determine the directions of the TE goal defining. Technologies are the measuring and observation instrument used for the passive or active observation of nature. The role of instruments in bringing about changes in scientific beliefs are the models of how the natural world is perceived (Hackmann, 1995). Technologies are tools for studying nature. The laws and the models as such do not determine the directions of the development of the goal defining in TE because cause-effect functioning and reasoning in the natural sciences is different from the function of an artefact. Means-ends reasoning and explanations cannot be deductively derived from phenomena and vice versa (de Vries 2018). A specific phenomenon in nature is not usually in itself a matter of interest in TE, but it could be something of the nature related to materials if the effects of man and culture on it could be eliminated (Anttila, 1988).

If the learners' learning goal in science education is to observe and understand the life of worms and the transformation of waste into soil, learners can plan and construct a composter that includes windows and an irrigation system in TE. Finally, they can use the finished composter in their learning actions in the classroom. However, their main goal was not to test the product in action, but to learn and observe the natural knowledge. The determinism of nature does not allow them to rely on the subject's own "producing" approach. In any case, determinism forms one's approach to defining the TE goal, such as the laws of physics and chemistry needed to learn and understand structures of the products and systems.

The knowledge of the built world has brought technical sciences alongside the natural sciences and humanities (de Vries, 2011). Engineers can have knowledge about the physical nature of the products and systems, knowledge about their functional nature and knowledge about the relationship between physical nature and functional nature (e.g., knowing that a certain material property makes a device suitable for a certain purpose) (de Vries, 2016). Engineers seek to state laws and seek to describe the particularities rather than the generalities (de Vries, 2011). Perhaps the most extreme approach in defining TE goals by engineering is technocratic determinism. The development of technique is determined by technical laws which directs the TE goal defining. The negative and harmful effects of technology can eliminate and correct only by technology, and human life improves by increasing techniques—the power of engineering knowledge and techniques (Parikka et al., 2011). Applying Niiniluoto's (2020) definitions of technocratic thinking, it is noteworthy that technology learning goal defining can take place without reflections on the values of the technology.

A teacher can provide a learner with a goal for understanding how an electric car operates and how to plan their own miniature electronic car. If the teacher says the car prevents pollution of nature without

explaining why and does not compare the electric car to alternative cars and their energy sources, the goal meets the top features of technocratic determinism.

Aestheticism of technology refers to ways of looking at the world devoted primarily to design and indifference to technology theory knowledge. It relates to design knowledge and humans' experiences of using, enjoying, valuing and critically appraising technological products and systems in this study. An aesthetic approach emphasises an interrelated relationship between humans and existing design. The design of a product can be considered through the eyes of professionals, but the product users and those who enjoy the product give special meanings for the design thinking. The impact of the historical and cultural heritage of technical developments on the design of technology also form an important societal part of the experiential approach (Ankiewicz, 2019).

In TE goal defining, this relates to defining the design impacts of ready-made products and systems and comparing them with the learner's own product views and experiences. Products have both positive and negative social, cultural and environmental impacts. An important question is to ponder and define what the aesthetic learning objectives are that shape learner valuing and/or critical appraisal of the product using and knowledge of its design. The aestheticism approach highlights beauty and taste of a product by taking into consideration cultural and social product using experiences.

When the goal of TE is to develop a product package for driving a simulation racing car comprising computer controllers and a seat, the learner can evaluate aesthetics and functionality of the same kind of product package. The products and experiences of the game culture are the predominant factors from which a learner defines what device solution is suitable for their own use. That refers not just what a learner feels and knows of the earlier solutions aesthetics, but how they could relate to their self-expression and to influence own product developing.

In summary, the voluntarism approach relates to a learner needing to affect technology and to produce artefacts or technological systems. The determinism of nature approach relates to a learner understanding and explaining natural phenomena. Often the learner needs to develop techniques to do so. The deterministic laws of natural science in the TE goals can also serve as the basis for a learner to think why technologies have been produced in nature and how nature could be protected through technology. The determinism of nature and the voluntarism form so-called general definition approaches for defining TE goals. The technocratic determinism approach and especially the aestheticism of technological cultures approach can bring more tangible TE goals to be defined to mind faster. They form so-called objective definition approaches.

TE goal defining alternatives

A joint examination of the closest approaches leads to defining more specific definitions in middle of the circle (see Figure 1). They have been described and applied from Freenberg's (2007) four alternative definitions for technology.

Instrumentalism is based on technological laws and the learner's free will for producing a unique product. Technologies are "tools" ready to serve the purposes of learners. Technology is deemed to be "neutral" and without valuative content of its own. Technologies are incidentally related to the learner's substantive learning goals they serve. Instrumentalism is more interested in a learner's individual educational purposes than cultural and social purposes like substantivism and critical theory. The sociological neutrality of technology is usually attributed to its "rational" character, the universality of the truth it embodies. What works in one school can be expected to work just as well in another, as technology is neutral and has the same norm of efficiency in any school. There is a price for the achievement of environmental and ethical goals, and that price must be paid in reduced efficiency (Freenberg, 2002.) Instrumental values play an important role in technological activity and may be classified as moral and competence based. The values encompass concepts such as ambition, open-

mindedness, capability, helpfulness, honesty, imagination, intellect, logic, responsibility, and self-control (Ankiewicz, 2019) Defining the TE goals emphasises that a learner can define the product goals for their production.

Determinism supports the view that the development of technological outcomes and systems determine future learning goals (Ihde, 1990). Determinism directs the TE goal definition towards productions of technology and their nature relationships and nature use. According to Kline (2003), sociotechnical systems of manufacture contain all the elements needed to manufacture a particular kind of hardware, work system, legal, economic and physical environments. In this study, the definition of a sociotechnical system of manufacture is limited so that deterministic information from the natural sciences and technical sciences form the core of the production knowledge in TE. The technological success of the theories is confirmed in uses (Smithurst, 1995) and technical devices can be seen as concatenations of causal mechanisms (Freenberg, 2007). Determinism-based TE goals can be linked with a learner understanding technological systems and problem-solving ability, such as modelling and developing mechanical series or electronics applications.

In this study *substantivism* emphasises technology appraising in the relationship between nature and culture. Aesthetic functional products and systems can be the core of the thinking, but they cannot be controlled in pure definitions of substantivism.

Substantive theory claims that what the very employment of technology does to humanity and nature is more consequential than its ostensible goals. Technology constitutes a new cultural system that restructures the entire social world as an object of control. Technology is characterised by an expansive dynamic that ultimately overtakes every pretechnological enclave and shapes the whole of social life. Total instrumentalisation is a destiny from which there is no escape other than retreat. The transition from tradition to modernity is judged to be a progress standard of efficiency and alien to tradition. The substantivism of technology attempts to make us aware of the arbitrariness of this construction and its cultural character (Freenberg, 2002.) *Technology is not simply a means but has become an environment and a way of life. This is its "substantive" impact* (Freenberg, 2002, pp, 8).

Technology object choosing is an important part of the substantivism of TE because the purpose is not to ponder the object of other ideas. The object contains certain values and according to which, technology is not interpreted mechanically or instrumentally as being available to the learners when they need them. Technology is defined as a force that transforms an entire culture that cannot be functionally identified. The substantive values of technology involve a commitment to a specific conception of the good, and if learners use technology, they are committed to a technological way of life, with means and ends linked in the system thinking (Freenberg, 2007). The aim might also relate to thinking about natural physical nature and acting by simultaneously using nature as the ends and never merely as the means because it is also necessary to move from eco-philosophy to eco-practice. In this regard it is noteworthy that natural contract is global and social contract in it is always local (Huttunen & Kakkori, 2021). TE goals can guide the learner, as a consumer planner, to save and develop technology in a nature-saving way. It can also think which technologies could be suitable in the learners' own culture versus globally, and whether the technology system needs to be built or not.

Critical theory agrees with substantivism that technology is not as uncritically welcomed as instrumentalism and determinism. Humans can submit technology to a democratic process of design and development. The values embodied in technology are socially specific and are not adequately represented by abstractions such as efficiency and control. According to critical theory, it is a meta-choice, a choice at a higher level determining which values are to be embodied in the technical-aesthetical framework for TE. *Technologies are not seen as mere tools but as frameworks for ways of life* (Freenberg 2007, pp. 14). Critical theory is relatively skeptical about the capacity of human beings to get technological civilization under reasonable control, but at least it does not exclude the possibility in principle as does the extreme idea of substantivism (Freenberg, 2007.)

There is little that a learner does that negates the need to engage with modern technology and therefore technology can frame multiple ways of life (Dakers, 2011; Freenberg, 2007). If a TE goal consists of knowledge of using, designing and making a product, but is devoid of links to a learner's hermeneutical thinking, it will also ignore the learner's life situation connection with learning technological literacy, critical theory not related to a learner's "own" design thinking (Dakers, 2011). Learner design cannot be based only on choosing and developing a means-ends product or system but must also include their experiencing, exploring and defining of it for their own product planning purposes. Learner aesthetic knowledge of product and one's own vision of the product forms the bond by which they define the means with the ends of the product design.

The approaches and alternatives

Technology is autonomous of *the determinism of nature approach*. Technology is a separate part of natural science, but technology can be an instrument to aid nature science. On the other hand, natural science knowledge is needed for the management and development of technology. According to substantivism, we are committed to a technological way of life although the values embodied by technology are pursuit of domination and power (Freenberg, 2007). According to determinism, the techno-scientific approach determines the direction of technology. In these two approaches the TE goals may be defined from finished products and systems information and their relationship with nature.

In turn, according to *the voluntarism approach*, technology is humanly controlled. TE goals may be defined from the learner's world of life on which their product design can be based and which it can begin. Instrumentalism seeks to invent and produce new products and systems, and critical theory uses existing design and the cultural factors that influence it.

The technocratic determinism approach is defined as technology is neutral. That means that technology must have complete separation of means and ends. Efficiency is the only value of technology. According to determinism, technology is rooted in nature and in generic features of the human species as a rationally constructed tool serving human needs. According to instrumentalism, technologies are tool systems ready to serve human purposes. (Freenberg, 2007.) In the definitions of TE goals, the separation of means and ends may aim to emphasise creating unique products, systems and production operations.

The aestheticism of technology is value laden. From the alternative of substantivism, values cannot be controlled, but we are engaged with the world in a maximising and controlling fashion and influences, and so this approach to the world determines a technological way of life. In critical theory, technology frames not just one way of life but many possible ways of life, each of which reflects choices of design and extensions of technological mediation (Freenberg, 2007). Substantivism and critical theory emphasise aesthetics, design knowledge and cultural experiences of technology impacts and developments for defining the TE goals.

Critical theory and substantivism would seem to be the most related of these four alternatives to romantic anti-technology. Learners and teachers are dealing with romantic anti-technology if technological devices and activities are understood to produce evil things and correcting the situations necessitates activities other than developing new products or technological systems (Parikka et al., 2011; Niiniluoto, 2020). The learning objectives under this premise may also relate to the definition of old proven products and their development or restoration or recycling.

Method

Research context and empirical question

Craft science or craft education is the main subject at the bachelor's and master's level of craft teacher education in Finland. Craft teachers in comprehensive and high school education must have a master's degree. The craft subject comprises mainly product design, research methods for creating and testing unique products, technologies of wood, metal, plastics, electricity, mechatronics and textile work and some mechanical engineering, information technologies such as technical drawing and 3D modelling and also pedagogical craft studying. The focus area of Finnish craft science is formed by science of education in combination with technical sciences and aesthetics of technological cultures (Metsärinne, 2021.) One of the main purposes in Finnish craft has been to change learners' life reality and perception of the craft and technology through their personally created and guided production projects. In TE an expansion of the technological world view and orientation and making of new product development and techno-scientific innovations is more deeply emphasised.

The sample of this study is from the course named Craft Technology Education. The aim of the course in Craft Teacher Education was to familiarise craft student teachers with the international theories of TE. They also have to plan TE learning tasks for junior and high school teaching and learning. The student teachers engaged with self-directed and literature-based learning, as there were two formal hours of lectures in the course. Neither this lecture nor any of the literature chosen by the students was related to the frame of reference for defining learning goals presented in this article.

Students had to find the theories and delve into them, choose one topic and define the TE goal for planning a new learning task. Students' decisions were not limited in any way. They had also to develop teaching material for guiding the learners' learning process. Instructions comprised three parts: 1) Read, choose and justify one topic, 2) Define a TE goal, and 3) Describe how you will present the task with the learning material to the learner by considering what goals the learners can define themselves.

The empirical question in this article is: "How do TE goals of the craft student teachers (n=100) relate to the alternatives for defining TE goals and how are they divided in the four alternatives?"

Data collection

The research data were collected from the students in the master's programme in craft education at the University of Turku, Finland between 2012 and 2019. From 2012 to 2014 the data were collected within the TE of craft course (n=62). The rest of the data collection (n=38) was collected in other master's level courses. Student participation in the data collection was voluntary in all the courses.

Data analyses

Student teachers' essays were analysed according to three stages. In the first stage of essays, the goals that were related to approaches of voluntarism or the determinism of nature were categorised. When the goal allowed a learner to define their own product goals for product design and making, or when the goal based on product design information for a learner product design and making, the goal was categorised in the approach of voluntarism. The deterministic goals orient and emphasise the learner to learn a particular technology directly and in most of the cases without the requirement to make a complete product. Therefore, the determinism of nature is not, as such, the basis for classification, but a goal as part of nature, as part of the exploitation of nature and part of understanding the technological construction.

In the second stage, the goals of the alternatives were analysed. The core criteria for classifications of the alternatives were: 1) Substantivism. The goal emphasises the learner acquiring knowledge of a product or system and its effect on nature and culture; 2) Determinism. The goal emphasises the learner acquiring knowledge of product or system operation principles and their production; 3) Instrumentalism. The goal emphasises the learner to define their own product or system goals for their own production and to acquire knowledge of some product or system operation principles and their productions; 4) Critical theory. The goal emphasises the learner acquiring design knowledge of a product or system and to gather information on its culture effect to be able to develop and make their own product or system.

In the third stage of the analysis, the most similar and thus the most difficult goals influencing the classification are compared to reflect the perception of the classification done. In the fourth stage, according to the classifications, ancillary objectives are analysed in the learning materials. For example, when the main goal guided a learner to search and understand the basics of CNC-technology and apply it to create a product using a CNC milling machine, the ancillary objective guided the learner to find out what different professions this information applies to, and what products comprise CNC technique parts. This ancillary objective was interpreted as supporting the learner's postgraduate study choices. When the four classifications' ancillary objectives were read, compiled and analysed several times, some of the goals could be found in each of the four main goal categories as learning "entrepreneurship".

The aim of the third and the fourth stages of analysis was to describe the qualitative differences and similarities between the goals, to clarify the rough classifications from the first and the second stages.

Findings and discussion

Forty-three TE goals related to the determinism of nature approach and 57 to the voluntarism approach. Some of the deterministic goals included requirement for the learner to develop or model a particular product. Most of the deterministic goals were related to promoting an understanding of technology that did not involve the whole product development. The goals were evenly distributed across all the alternatives.

Table 1. ***Sample of Six TE Goals in the Alternative Definitions for Technology***

Substantivism (n19)	Critical theory (n27)	Determinism (n24)	Instrumentalism (n30)
Wood gas in electricity generation in the 2010s	*Motorcycle maintenance and repair procedures*	*Audio recording from phonography to the present day*	*Electric motors and electrics of creating and manufacturing vehicles*
Basics of diesel technology	*Music descriptions and instructions of electric guitars for own guitar design and making*	*Steel industry, -refining and blast furnace operation*	*Understanding structures of products to create a miniature bridge*
Renewable energies (geothermal energy, wind-, solar-, bio- and hydro power)	*Instructions for restoring old products*	*Theory of programming and automation technology*	*The basics of fuzzy logic to produce a reversing radar*
Nanotechnology, -materials, -structures and applications	*Car painting and its alternative painting methods*	*Familiarise yourself with the technical operation of your computer*	*Through mechatronics to equipment constructions*
Lighting technology development history	*Programming microcontrollers in product design*	*Understanding electrics writing diagrams*	*Common metal processing methods to produce metal products*
Construction of log houses and a guide for school project work	*Use of information technology programmes in product design*	*Operation principles and theories of the air source heat pump*	*The theory of strength and examples of it in products for producing chairs*

Instrumentalism

Technological life improvement and understanding technology were "basics of strength theory*"* which have goals for product creation "build a tower". Other goals have included acquiring knowledge of product or system operation principles and its production for one's own unique product production as in "learn automation device operating principles, do programming exercises and produce own automation device". These goals can be interpreted as envision-based or project-based instructions of the explorative learning method for creating a unique product or system theory and testing that theory (Kallio & Metsärinne 2017; Metsärinne & Kallio, 2017).

Critical theory

The goals based on the design and use of products were "acoustic guitar (structure and parts, body, tuners, electronics/microphone operation)" for design and making a "plan and make your guitar with the instructions". These goals can be interpreted as referring to methods of learning product or system development, making and evaluation. The goals might also relate to the ideas of technological do-it-yourself and maker cultures. According to Nascimento and Polvora (2018) maker cultures can be seen as potential spheres of opposition to deterministic trends to develop users into active designers, producers and distributors of knowledge, tools and machines and within that technology needs to be

understood more complex than it usually is, not limited to individual assertions of freedom and creativity.

Determinism

The goals to learn and understand product or system operation principles and its production were "the goal is to understand the operation of digital technology and electronic logics as well as to get acquainted with the construction of a mobile phone and make own mobile". Some goals only focused on production: "how to use of precision wood (laminated table)" and "operation principles like 'radio control driving'". The goals can be interpreted as referring to methods of problem solving and modelling. Modelling here means that the student learns to understand the basics of the operation and construction of a product or technical system and sometimes build it themselves.

Substantivism

The goals to acquire knowledge of a product or system and their using and effect of nature and culture were "basics of level learning of materials systems from materials and energies to product constructions" and "what green technology is, photovoltaics and familiarisation with the manufacture of a zero-energy house". The goals can be interpreted as referring to methods of understanding material technologies and also their using and maintenance or restoration as "learn and reflect on the common meanings of environmental science and crafts and present a plan for product restoration" and "construction of log houses and a guide for school project work".

Similarities and differences of instrumentalism and the critical theory

The goals could be viewed as two different goals. The student must produce a product or system and must learn some technology. The similar goals of the approaches were to strive to produce a quality product that specifically includes the goals of producing the most personal and useful product as possible, as in the following examples. One goal of the critical alternative was "get acquainted with different forms of grilling heating and grilling styles related to outdoor barbecuing and define how they affect the design and make of your barbecue". One goal of instrumentalism was "repeating the basics of metal and wood techniques, and basics to learn TIG welding and plan and make your own product for your life improvement by using technical work techniques".

Most of the critical theory goals related to the design and make of a learner's personal product based on the orientation of certain finished product features and a learner's personal experience with them, such as "furniture style trends", which included the goal of "design a seat for personal use". Most of the instrumentalism goals required a learner to produce their own product by learning some technologies but most often the goals do not include what the product should be. Such a learner goal was to "learn CNC milling basics and design and make a meaningful product". Occupational safety learning goals were similar in the alternatives. They mostly related to ancillary goals that the learners have to learn and plan safe manufacturing processes and learn the correct work habits.

Similarities and differences between determinism and substantivism

Most of the goals have no product or system production requirement for the learner, but some of them have restoration, maintenance or modelling requirements. The goals of these approaches related to the history of technology and sustainable development like in the goals emphasised in learning technical development of the products in determinism and the goals emphasised in learning life cycles and the effects of products in substantivism. The determinism goal was "to find out the main technologies that

influenced the development of the phone". The substantivism goal was the "production and reuse or recycling of electronic and mechatronic systems". The learning of materials technologies was emphasised in the substantivism goals and the learning of products' technical structures was emphasised in the determinism goals. The exception to this classification was material processes that were clearly only related to the learning of industrial processes. In that case they were classified in the determinism goals as learn "electrolytic coating methods and their potential". What goals the alternatives had in common was that they typically described some of the learning basics about the product or system production processes.

Similarities and differences of determinism and instrumentalism

There were similar goals related to understanding technology theory, like "electric motors and electrics of creating and manufacturing vehicles" of instrumentalism, and determinism "learning the basic connections of electronics and combining the connections with the alarm system constructing". Both these goals related to understanding technologies of a product or system and their production operations. However, in most of the determinism goals, the theory construction for a product or system and its production was not related to the goals' requirement, but technology learning was limited to the understanding of technological theories like in the goal "basics of solar energy solutions".

Similarities and differences of critical theory and substantivism

The goals comprise certain information about product design or using the technological system. In critical theory, such as "fixed-gear bicycle design and tuning from a standard road bike", and in substantivism such as "what everyone should know about the operation of a nuclear power plant". The goals of substantivism were aimed at reflecting on the aesthetical and critical technological issues between humans and nature. Critical theory goals reflect on the aesthetical-technical relationship between the learner, their life situations and product use and design knowledge. A factor linking the differences between learning related to the aesthetics of technology in nature and learning design-based technology can be seen in their ancillary goals directions for so-called technological civic education.

The difference between the goals of substantivism and critical theory were also situations in which the learner was given a direct technology learning target. According to critical theory like "home maintenance operations", the goal involved a few school assignments and, in some cases, also homework. And according to substantivism, the learner was given more deeply theoretical goals to reflect on and learn about technologies like "hybrid car", which involved another goal as a question: "How can I influence the development of technology now and in the future?" These goals were not directed to practical school assignments. However, both approaches have goals about product maintenance, repair, reconstruction or restoration operations, but the goals of substantivism included only two goals where objectives direct students' own whole product producing as "craft heritage meaning in TE and learning to produce a sheath knife".

Similar ancillary goals were found in all the classifications. These goals were entrepreneurship, safe working, technical literacy, surface treatment methods and knowledge and skills related to postgraduate study.

Discussion about the alternatives

It can be interpreted that the goals of determinism and instrumentalism direct learners to learn and understand technical production and how products and technological systems operate more deeply than

the goals of substantivism and critical theory. On the other hand, the goals of substantivism and critical theory can be interpreted as leading to learner thinking through their hobbies or related activities or thinking through technological values in nature and culture more broadly than the goals of determinism and instrumentalism.

One might think that the goals of determinism and instrumentalism form the core of TE and the goals of substantivism and critical theory would also be implemented in other school subjects. That could strengthen the role of engineering knowledge in TE. That knowledge has declined significantly in Finnish technical work in craft in the 21st century. An important role in this respect is how technology is considered in the arts, in the natural sciences and in the social subjects for junior and high school learning. On the other hand, the goals of critical theory were comprised of extensive knowledge of technical skills with design knowledge and the goals of substantivism comprising theoretical and general background information for using critical appraising and producing technologies. The question of what all learners should learn about technology is clearly more strongly emphasised in substantivism and critical theory than in the determinism and instrumentalism goals, which in turn placed more emphasis on individual self-development as well as more deeply theoretical technology learning. Because of this, the goals and learning content according to the substantivism and critical theory cannot be assumed to be taught enough in other school subjects but belong to TE.

The four alternatives show that the student teachers considered the broad and different goals important for TE. Finnish craft student teachers learning about craft at university and learners learning craft in schools have been emphasised more deeply from the voluntarism goal approach than from the deterministic goal approach. Emphasising this voluntarism approach differs from how the student teachers defined the goals in this study. For this reason, differences that might refer to considering such learning goals more deeply and contents that relate to learners' life situations and their relationship with nature than relate only to learners' personal design and making. The use and application of the alternatives of determinism and substantivism goals with knowledge of finished products could add more to the education. Substantivism emphasises user and nature viewpoints and determinism emphasises developer viewpoints by using nature.

It is also possible that the student teachers have sought to define the goals of substantivism and determinism with better support of learners' own product productions at later learning processes, even though they have not written such aims. According to the sample of student teachers, it can be interpreted that the goals of substantivism and determinism could consider the planning goals in more depth.

To learn these things, studying about theory of technology with modelling or remodelling techniques in practice could also be increased. If these contents were added to the school education, then contents aimed at learning to produce learners' own personal, creative and practical so-called whole product production from start to finish would get less time. Given this, it is not surprising that goals like in instrumentalism and critical theory are usually emphasised more than the goals like in determinism and substantivism in craft education.

The theoretical-practical construction of learner technological production is based on the learner's self-defined product and production goals according to instrumentalism or on basis of the general product design goals according to critical theory. The goal of both is whether the product created is fit for the intended function. Whatever the general goals given to the learner, without the learner's own definition of product goal, the learner's own production based solely on modelling or developing the qualities from a previously-known product and not on their own created production. That is why the learners defining their own goals are not the same as defining the goals from finished and tested results from a product, its production and use.

It is notable that none of the student teachers' (n100) TE goals related to learning textile work, at least from the Finnish point of view. The learning tasks in the courses in craft teacher education are not

limited to the use of only some techniques and materials after basic skills learning, but rather they are encouraged. When the student teachers had freely defined the goals in this study, they can ponder that they do not think of textile work as part of TE. This can be influenced in the thoughts that TE and Finnish technical work of craft are seen almost as being synonymous (see Kananoja, 2009), even though TE has not been a school subject in Finland. TE is defined as relating to teaching in several subjects. However, the history of Finnish school craft shows that it has followed similar lines of development in the TE subjects in other countries (Marjanen & Metsärinne, 2019).

Conclusion

The TE goal defining framework compiles comprehensively the outlines of TE goals defining. On the other hand, the sample used here described only the major differences and similarities of the goal approaches. And given that craft student teachers were not aware of the theoretical framework of this study when defining learning goals and writing instructions about using the learning materials, the impact of the theory for the defining cannot yet be considered. However, the divided analysis of the sample encourages development of the theoretical framework. In the future, the theoretical differences and similarities between the various parts of the framework need to be examined in more depth. In this regard, it should be noted that Freenberg's (2007) four alternative definitions of technology were applied in the approaches taken in this study. The theoretical framework should be considered in a completely different way, if it will consider Freenberg's broad critical theory basis and its relationship to the other alternatives and theories (Freenberg, 2002).

Using and applying the scientific basis of TE and its philosophical foundations is important in defining the objectives of TE in order to inform and illustrate to learners its diverse meanings and dimensions for the purposes of general education and postgraduate studies. In this sense, the framework could also provide opportunities to design and define interdisciplinary and phenomenon-based TE objectives. Within the framework, it would be interesting to explore how TE goals link to STEAM (science, technology, engineering, arts and mathematics) learning goals, how they differ from them or how they merge in the STEAM goals or how STSE (science, technology, society and the environment) viewpoints could be considered in planning the goals.

The main conclusion is that the framework of defining TE goals might provide a fairly broad and versatile but still consistent theoretical basis for the defining. In the future it would be interesting to study more deeply the theoretical relationships of the approaches and the alternatives, what learning goals are in schools compared to the framework and how they might form a coherent learning continuum at different levels of TE.

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