PRODUCTS AND PROCESSES

Farewell lecture by prof. Kaarle Kurki-Suonio held on Thursday 29.1.1998.

Prologue

Yesterday I reached the age limit of statutory senility. Now I can, with a clear conscience, leave the squirrel wheel of the exponentially growing centrally managed anguish of the University of Helsinki. To honor this event I have invited you today to listen my farewell thoughts. After passing the stake pole I am no more, by law, officially responsible for my thoughts. This, of course, facilitates holding this lecture. However, in order to preserve some sense, I have marked down some notes, which possibly will help me in piloting through my last thoughts.

I regret, that I have to resort to the aid of technology. Sometimes in past years the students claimed to be able to follow my lectures behind two doors in the library. I can no more boast about that. I have sacrificed my voice on the shrine of science and teaching.

It is long since I entered this hall for the first time. It was the autumn 1950, when I attended the first-year physics lectures. Reino Tuokko, who later gained fame in popularization of science, held the course. The relation of teaching and popularization is, in fact, also part of today's subject.

My subject is neither technological nor commercial, as one might conclude from the title, but I shall ponder in my lecture physics teaching, physics, science and art - and finally, the good and the evil.

The cultural heritage of science

Richard Feynman, undeniably one of the great genii of the now-ending century, held 35 years ago his famous lecture course, which was also soon published as a textbook[1]. Every physicist ought to know that book. To start with, *Feynman* asks about the cultural heritage of science (Vol. I, Ch. 1-2). Imagine, that the whole human culture was to be destroyed in some cataclysm, and that some super mundane demon would allow us to pass on to a possibly arising new culture just one sentence. *Feynman* asks, what statement would be the most valuable one? He does not give a definitive answer, but suggest that `*All matter consists of atoms*` would be a good candidate for such a sentence.

This represents the prevailing ideal of physics teaching. Take a look at the textbooks of primary school and you will see how our children are guided into the secrets of Nature. The first references to physical and chemical phenomena are regularly sentences concerning atoms, molecules and electrons. This impression will only be enhanced if we browse the textbooks further. At almost every subject the teaching starts with atomic models without the slightest hint to what they are supposed to explain.

There is a serious problem. Leaving *Feynman's* atomic sentence as the heritage of some newly arising culture contradicts the most central principles of Western science. It teaches: "Believe this divine word, there is the truth." This is not polemic against religion but against the practices of physics instruction. `*All matter consists of atoms*` cannot mean anything to a newly starting culture. It cold adopt the sentence as God's word, frame and hang it on the wall, gaze it with admiration, perhaps light candles in front of it, if there are candles in the culture, and worship it. But that is all that is available form the sentence.

Some twenty years ago I gained a somewhat questionable reputation amongst the teachers by launching the concept *"formula disease"*[2]. I, thus, polemicized against such practice of physics teaching, where it is spoken of in terms of formulae without any reference to their meanings. The teaching proceeds in the style: this is the formula, you shall learn later what it means.

A citation from *Feynman's* book fits in here. In Ch. 4-1 *Feynman* asks, *"What is energy?"* and leads the reader as follows: *"There is a law governing all natural phenomena … called the conservation of energy. ... That is a most abstract idea, because it is a mathematical principle; ...It is just a strange fact that when we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same. ... There are formulas for calculating some numerical quantity, and when we add it all together it always gives the same number. It is an abstract thing in that it does not tell us the ... reasons for the various formulas."* (Underlining are my own.)

Feynman's text is superb. In those times, when I was making my first trials of teaching and was learning to

[1] Richard P. Feynman, Robert B. Leighton & Matthew Sands: *The Feynman Lectures on Physics.* Addison Wesley 1963

[2] *Formula disease - symptoms, care and prevention.*(In Finnish) Matemaattisten Aineiden Aikakauskirja 44, 1980, 147-153.

write textbooks, I wished hard to be able to write anything corresponding. But, what is taught here: Energy is an abstract collection of formulae. The conservation law of energy means, that calculation with these formulae will always yield the same number. Energy and conservation of energy are presented as finished products of science, *'abstract ideas'* and *'strange facts'*, which are not even needed to be understood in any other way than as formulae.

The children's response to physics teaching is shocking. When asked, what in physics pleases them and what does not, almost hundred percent of the answers contain the message: "The most disgusting thing in physics are the formulae." And, when the question is posed in the comprehensive school, atoms and electrons equal the formulae as disgusting things, disgusting because they have no connection whatsoever to the pupil's own environment and observational world.

Our instruction is full of well-packed products, ready formulae, the meanings of which the pupils cannot have any idea about. We just imagine and wish, that also the meanings would sometimes be cleared up for the pupils. Ordinary formulae, or algebraic expressions and equations, represent just a small part of distribution of products in the instruction. The idea of formula is very general: *thoughtless-reduced operational instruction*. This is the essence of formula. Even the experimentalness of our teaching is full of formulae, thoughtless-reduced instructions: take this thing, that thing, push that button, read the meter and record the reading in a table! The tentacles of the formula disease extend everywhere!

The idea of formula involves, however, something, which is intimately attached to the aims of science. It is often said, that this result has already been derived by someone, why would it be necessary for me to derive it or to prove it again. It is sufficient that I know the result and can make use of it. Someone else has already invented this, I need not invent it anew, using it is sufficient. Making repetition of a process unnecessary in such a way belongs to science. The formulae and knowledge about atoms are important results of science. But what do the pupils gain, when they are served in the teaching with finished products, just to be accepted? A formula can be an aim of science but it is not a tool for teaching science.

Arnold B. Arons, late professor emeritus of the University of Washington († 2001), visited Helsinki some years ago. He has published a heavy address[3], heavy both weighed on the scales and by contents. He states that physics teaching is bankrupt. Research has shown, - or as people say 'science has proved', - that in such knowledge and skills called *scientific literacy*, a vast majority of university physics students are on the level of children just starting school.

Lucid explanation

Interviews of students intending to become physics teachers reveal, in an interesting manner, a unanimous idea about the nature of teaching: The ideal of good teaching is lucid explanation. When I saw for the first time the university questionnaire for student inquiry about the quality of teaching, I found also there the question, about whether the teacher is able to explain clearly even the difficult points, which shone out as the most central item. Contrastingly, I could not find even the slightest hint of, what is the most important element of learning, the student's own process, and to inquire, whether the teacher is able to provoke and to promote it. Also the students' own evaluations concentrate mainly on the question, how clearly the lecturer is able to explain. It is seldom that attention is paid to the ability to induce one's own thinking in the students.

Atoms and formulae are corner stones of the pedagogy of lucid explanation. Observations and experiments are there only for confirmation of the explanations, if even that. A prototype start of comprehensive school thermal physics characterizes the role of experiments in the lucid-explanation pedagogy. According to the text book and the teachers' guide the teaching proceeds broadly speaking as follows: There are two vessels on the teacher's desk, one with cold and another with hot water. The pupils walking in a queue dip their hands alternately in the hot and cold water, observing what they might observe. When they have returned to their seats starts the INSTRUCTION. "Well", says the teacher, "heat is motion of molecules". There we have a typical "lucid explanation", an explanation, without any comprehensible connection to the observations - or perhaps though, after a years long process, but, for sure, not in that classroom situation.

This is nothing but continuation of the ancient tradition where science was a matter of the priesthood! The physicists are interpreters, priests of science, penetrating to the mysteries of atoms and formulae. These sacral products they graciously distribute guiding the peasantry into the rituals of correct respectful use of them, but the holy secrets remain in the possession of the clergy.

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[3] Arnold B. Arons: *Teaching Introductory Physics.* New York: John Wiley & Sons 1997, 775 pp.

This is not solely a problem of physics. This was revealed to me a couple of years ago by the doctoral thesis of *Pirjo Karvonen* (At present *Pirjo Hiidenmaa*, The Research Institute for the Languages of Finland) on the field of Finnish language research. It dealt with textbooks on Geography and Biology. It had become strongly evident that in the textbook text the first sentence on a subject has always the nature of a definition. The subsequent sentences then specify this definition. Declaration of final indisputable results is just the tradition of instruction. The mouth of the pupil is shut by the very first sentence. The process is cut at the start.

However, as is well known by all physics teachers, this is just what the pupils want. They wish to get final products, ready answers to be learned by heart and to be repeated word by word. *Arons* adopts here the word *regurgitate.* This is a delicious metaphor. Repetition without understanding is 'regurgitation'. We are teaching the pupils to regurgitate - atoms and formulae. And the pupils love regurgitation. If we, instead, wish to teach in physics '*scientific literacy*' we meet strong resistance to change, teachers and pupils in a united front.

Where does this initiate? Every child observes. Every child interprets. Every child learns meanings of expressions in his native language. Observation of ones environment, analyzing perception of the properties of observable entities and phenomena, which gradually leads to concept formation and conceptual understanding, starts at birth, maybe even earlier. Where does this natural process stop? Do we cut it with our instruction? How could we, instead, by our teaching, encourage the pupil to continue the process, so that he could preserve his confidence on his own observation, I see, I hear, I feel and I am myself able to interpret my observations and make conclusions? The question is more of a lack of courage than of a lack of ability. The fear of not understanding, not being able for the process, makes one wish final products, which need not be understood. The fear of not digesting generates regurgitation. For the *scientific literacy* to proceed, the pupil must be helped to overcome his threshold fear, to keep the confidence in his/her own observations, own thinking and own process. This does not mean confidence in obsessions, but confidence in ones own observations and thinking so firmly, that one dares to change ones preoccupations on that basis. This is not very much advanced by statements like *'that is a most abstract idea', 'it is just a strange fact that'.*

Cream and sausage

At this point I thought that the subtitle could well be also "My Father and Feynman", a homemade version of the theme "My granny and Mannerheim"[4]. Namely here my father is marching into the arena. He was studying at the University of Helsinki in the second decade of the present century. I have been fascinated by his amusement about the fierce discussion that took place concerning the site of the university campus. The Students' Union was strongly against all sites proposed: "Not so far outside the City!" My father said: "History is repeating itself." In my student times building of the 'Old Student House' on its present site, in the very heart of Helsinki centre, was planned - and the Students' Union opposed strongly: "Not so far outside the City!"

My father was a doctor running a private maternity hospital 'Höyhensaari'[5] in Hämeenlinna. "*Cream and sausage* " is a shivery true story told by him. A newborn baby was not developing well enough in the opinion of the grandparents. They thought the food was too meager. So, they feed the baby with cream and sausage. The baby died!

My father did certainly not guess that he gave me an apposite diagnosis of the state of physics teaching. For a child `*All matter consists of atoms*` and all the splendid formulae are 'cream and sausage'. Well, sausage has not a very good reputation elsewhere, but for a male Finn it is just the best delicacy. When offering in our teaching the best products of physics we have fed the children with cream and sausage - and killed the sprout of physics living in every child, the promising start of the process.

The tremendous theoretical development of physics is a fantastic cultural achievement. But its relation to teaching is a problem. It has distorted our view about physics as a subject of instruction. The explanatory power of theory and theoretical models, which seems almost unlimited, has lead us into distribution of theory as the main contents, and at the same time into a mystification and, eventually, to the death of physics. In the sense of *scientific literacy* physics is scarcely learned at all.
Scientific literacy does not lie in the products but in the process. It does not consist of repetition of sentences learned by heart, or regurgitation, but the ability to observe, to interpret ones observations, to build up mental images with support of the observations and, in this way, to find the meaning of the mental images as explanations of the observations. In the teaching it is therefore necessary to learn to start from the beginning

[4] *Paavo Rintala*, a well-known Finnish author, wrote in the sixties a famous series of books with this theme.
[5] 'The Land of Nod'. Literal translation 'Isle of feathers! The land of safe and peaceful sleep for children.

in a new way, not from atoms and formulae, but from observations and investigation of the environment, in order to see and remember that Physics means basically representation of observations and development of mental images based on the observations, nothing more sophisticated. One has to stake more on conceptualization of observations than on illustration and lucid explanation of ready concepts.

So, let us change the cultural heritage!

Last summer (1997) the subject of one of my lectures on a complementary education course for physics teachers was *'Canonical half-truths'* [6]. These are just the cream and sausage, sentences like 'heat is motion of molecules', formulated as if they were clear definitions, but which do not mean anything for the pupil and are, thus, to be learned for regurgitation. Also *Feynman*'s sentence of heritage was discussed as a typical example. I was interrupted by a sharp question: "What would be the sentence of heritage by professor Kurki-Suonio? I turned the question back to the audience, and there it was: "*Investigate, and you will find out*." That was a great moment, a highlight! Something most essential of my message had been understood. The second motto of didactical physics education was born[7].

This heritage belongs to each pupil separately. Every one of them ought to become guided from asking, adoption and unquestioning acceptance of 'final correct answers', - which is difficult to distinguish from the nowadays so strongly emphasized ability of seeking information from various sources, - into *creation of knowledge*, building up of ones own world picture.

The invitation amongst my last thoughts was addressed to the 'friends and enemies' of physics teaching. The problem of process and product makes the question about friends and enemies problematic. We may be at the same time both friends and enemies, we are aiming at the good but we are acting against our good purpose. We are distributing beautifully packed 'final products' of science believing that we are giving the best, what physics has to offer. We are feeding the child with cream and sausage - and kill him. In Finnish folklore such disservice is called bear-service[8].

The paradox of physics teaching culminates in the course by *Feynman*. He is an uttermost example of an inspiring lecturer: verbal virtuosity, intelligent jokes, spiced by a pinch of conceited mockery of philosophers and educationalists. The book made from the course is magnificent, a treasure of every physicist. It is a wonderful course and a wonderful book - enrapturing all who already understand physics. It inspires strongly those, who have advanced far in their process. But it does not help to start. In the light of learning results the outcome from the course was not better than from courses held by less genial lecturers. Thus, for a pupil it is not a learning book, which would open the gate to understanding. The genius of the lecturer does not solve the problem of teaching.

Also development of instruction is still very much governed by the conviction that the idea of science, knowledge and understanding is hiding in the product. The lucid interpreters are developing ever more lucid explanations, wrapping them in new beautiful papers, CD-ROMs, multimedia and other modern delicacies. In fact, modern development of teaching, materials, means and tools is mostly generation of new wrapping papers, at high expense, around the same old idea of teaching gone bankrupt already long ago.

From organization of knowledge into process

This is a suitable occasion to present a summary of the history of my own textbook writing. At the same time, this tells something about, how my own ideas about teaching and learning physics have taken shape.

I have participated in creation of two textbook series for the upper secondary school. The first one had the title '*Kvantti' (Quantum)*. Planning of it started soon after the Curriculum Committee for Upper Secondary School[9] had started its work in 1975. Writing continued far into the eighties in close interaction with the development of the university courses of didactical physics. The starting point of '*Kvantti'* was the general principle of organization of physical knowledge, *'ladders of understanding'*: The treatment of any subject should give an idea about what observable *phenomena* (1) the subject deals with, what *quantities* (2) are used to represent these phenomena, what *laws* (3) do these quantities follow in the phenomena, what *theory* (4) and what kind of theoretical models can explain these laws, and further, what *applications* (5) or practical

[6] Chapter 4.1.4 in the book *Meanings and Structures of physics* by K. & R. Kurki-Suonio. Limes ry. Helsinki. 1994. (In Finnish.)
[7] The first motto, inscribed on the opening page of the book of footnote 6, is "Meanings are first."
[8] This originates from a folktale where a bear just wanted to kill a fly on the forehead of his master.
[9] I was at first on the Committee as a member of the Division of the Content Area of Natural Sciences, and later as a chairman of the Physics working group. In Ch. 1 of the book mentioned in footnote 6, I have described my experiences from this work.

significance do these phenomena have. Such a basic analysis was exercised on the courses for physics teacher education. In that connection it became gradually obvious, that this breakdown as such was just a structure of knowledge, although quite clarifying. What is essential is the coupling of the steps into a process of conceptualization of observations, proceeding from the phenomena towards the theory. This, however, caused surprisingly great difficulties for the students. It was quite puzzling to realize, how dominating was the inability to find observable phenomena as the starting point of a subject to be treated. An example from one of the very first courses in the beginning of 1980's has already become classical:

In one of the exercises a discussion of rotational motion was started. The students thought hard, what might be rotating and where rotational motion might occur. After a long silence someone noticed, spinning top(!), and after a while, merry-go-round(!). But then the ideas drained out and the supervisor had to lead forward. This probably hints at the stage where the process has been cut. One returns back to the memories of childhood, to the time, when the process still was alive. But never, in no stage, any idea had been developed about the point belonging to the very basics of physics, that rotation is, beside the translation, another degree of freedom of motion - all bodies rotate or can rotate. The process has been off through all the time they have enjoyed instruction of physics.

The second series, '*Galilei',* represents the 90's. Already in writing the '*Kvantti*'-series new ways of presentation were sought, different from the theoretical approach of the traditional textbooks and based on experimental starting points. '*Galilei'* is a conscious change from analysis of the knowledge structure into the process. It approaches systematically the, evidently unsolvable, problem: how it would be possible for a textbook to support the process in order not to be merely a collection of products.

Basically the question is about the scientific nature of teaching. The traditional way, starting from atoms and formulae, *i.e.* from the theory, Arons calls *backwards science*. I have been even more severe, because, how could science start from the results it is seeking. Progress of the studies is, of course, different from the progress of science. On some level of common possession of mankind or, at least of the scientific community, these products do exist. But the child does not yet own them. In his view starting from the final products is, not only *backwards science* but uttermost *non-science.* Scientific nature of teaching is sought by offering the newest products of science, although science lies in the process and not in the products. The primary task of instruction is not the popularization of the newest incomprehensible results of science, although that also has its justification. In the first place, teaching ought to help the pupil into his own process.

Distribution of products is a linear action. One product at a time is picked from the shelf: the first, the second, the hundredth, the thousandth … . The pace continues evenly and, if the capacity is sufficient, the pupil transfers the products into his own pigeonholes at the same pace. Linear instruction proceeds safely. The teacher can easily control the propagation in line of the curricular aims. Thus, the learning aimed at follows a linear law. New knowledge is learned, if learned, by heart at a suitable pace.

The process is different. This is obvious from the development of science. Science has proceeded and does proceed exponentially. When we are building on the basis of what is learnt and understood, the pace of growth of understanding is proportional to what has been already achieved. This is the law of organic growth leading to exponential development. This is the fundamental supporting idea of constructive learning. However, here the teachers running into great distress and trouble: "It is hopelessly slow to teach understanding, the scant hours allotted to physics are not sufficient." Why; exponential growth is always slow in the beginning, but at some stage it necessarily passes the linear one and, ultimately, exceeds it infinitely.

Learning is *an ontological process,* interaction of the human mind with the environment. Learning means organizing perception of the environment and the reality. There are two components inseparably intertwined, *the scientific process,* aiming at understanding, conceptual command of the environment, and *the technological process*, with the purpose of changing the environment to meet better the human wishes and needs. This process can certainly not be activated and promoted by feeding the child with something, which *`does not tell us reasons for the various formulas`*. In the process '*meanings are born first*'. They are learnt by observing and interpreting observations. They are *`reasons for the formulas`*. The turn of the *`formulas`* will come only when they are needed for representation of the meanings understood. *'By investigation you will find out'* the meanings for subsequent conceptualization.

Unattainable targets

Unattainableness of the goal is the great problem of the process. Learning, like science, aims at the unattainable - truth, or understanding which is ultimately the same thing. The reality is unattainable. I still believe in the old-fashioned way that the aim of the process of art is beauty, perfect beauty. In fact, only

unattainable aims can be genuinely valuable and interesting. But, when aiming at unattainable ideals, truth and beauty, the process is necessarily endless.

The process manifests itself in its products, but the products are not the same as the aim. Each product is a reached stage, while the process itself is endless. In fact, the products of science are not a set of finalized results but an endless chain of continually deepening understanding. In this way, even a product becomes a process. Knowledge, concepts and understanding are never ready, but they are developing continually in the process. Instruction, which starts from the products, obscures the basic nature of the progress of science, making it look like a set of separate bits of projects. In this way it strengthens the banal public picture of science as action, where products are changed in proportion as new ones are appearing.

The process of understanding is bound to consciousness and, thus, to the individual. But science, as an internal process of the individual, is impossible. Science, as well as learning, is an endeavor towards commonly understood meanings. Subjective perception of meanings in the minds of individuals does not suffice when objective knowledge is sought. Therefore, both science and learning are subordinated to *the social process*, 'negotiation about meanings' to find out, about what we can be of one mind. This linguistic term characterizes well the role of language in the creation of meanings. Although objective knowledge about reality is an impossible aim, it is possible to proceed towards it by seeking the intersubjective.

The limited scope of products, as compared with the unattainableness of the aim, leads to an internal contradiction within science and art and in all creativity. Products are necessary for the process to become apparent and to contribute the build-up of culture. But, when the goal is perfection, what ever it might be - truth, beauty, logics or completeness of a representation in terms of a logical structure - no product can satisfy, because the product is always finite and incomplete. Every creative researcher and artist wishes his products to reflect his aim. He is aware of its unattainableness, still he aims at it.

From mathematics one can get an inkling of what perfection might mean. A logically harmonious, mathematical conceptual structure is flawless, true and beautiful. Also in physics the use of mathematics reflects the same striving for perfection. At best a physical theory expressed in the form of a mathematical representation can be internally complete as a conceptual structure. Still, as a representation of reality, of some range of phenomena, it will always be incomplete, a model with a certain finite area of validity.

Logic belongs to science. From the point of view of teaching it is, however, important to realize, that logicalness is a property of products, not of the process. Presentation of ones results in a polished form, as finished as possible, structural, logical and beautiful, belongs to the proficiency of a researcher. Still, prominent researchers often emphasize the ultimate role of intuition behind their achievements. Hardly anyone can honestly claim that his thinking proceeds logically. Of course, we try to conduct our students into logical thinking. But learning itself does not proceed logically, neither does the research. Logic is a goal striven after. By practicing one can learn to find faster a logical structure for ones thoughts. The process becomes faster but it does not turn logical itself.

A kind of lie of science is hiding here. The results are presented as if pretending that they have also been created logically, *i.e.* in a 'scientific manner'. The process is hidden. One wants to give a picture only of the truth detected and the beauty achieved. The laborious process, its difficulty and eternal incompleteness is felt shameful and unscientific. This is manifested by the great amount of 'drawer research' found after many genial scientists. Gauss, for instance, is known for that. One does not want to let outsiders see the tedious search, the groping in the dark and the tracks of error. Still, they have been necessary for the process to proceed. It is there the secret of genius is hidden. We can hardly think what the process is like behind the beautiful logical product, how is the diamond cut. We are let just to admire the beauty of the finished diamond. Thus, the problem of genius, the intuitive core of the process of science, remains the private secret of Newton and the other genii. The layman can see just the final product and is thrilled: "science has proved that …".

As a consequence there is the paradoxical problem of teaching. The process can become evident only from its products, concepts, publications, compositions, works of art *etc*. We can show the products as proofs about the process hidden in them, but we cannot transfer the process to the others. With the aid of the products we may, perhaps, convey a picture of the ideal of perfection and, thus, encourage the pupil into his own process. But one cannot get one's share of logic or beauty in any other way than through one's own process, by going through the oppression and joy of the creation of the products in one's own inmost heart.

The secret process of the genii of the mankind cannot be handed over as a cultural heritage. So, the sentence I am offering instead of Feynman's atomic sentence, tells, in fact, just the simple basic fact, that each must go through his/her own process. The unrewarding, eventually impossible, task of the physics teacher is to help the pupil to uncover a secret, which even the teacher himself cannot know.

Joonas Kokkonen, a great Finnish composer and academician, mentioned once in an interview, that *Alvar Aalto,* the famous Finnish architect, condensed excellently the basic nature of creative work: '*passion towards quality'.* Here 'quality' means perfection never attainable. A product can never be good enough.
A small story about the great Austrian symphonist, *Anton Bruckner,* is a nice example. (The beauty of his 7th symphony, growing from emptiness, has sounded lately as our wake-up music.) He is conducting a rehearsal of a choir. I do not know which of his works was to be worked through, but I always imagine it was the mass in e-minor starting with a pianissimo of the sopranos high in the descant. The rehearsal starts. Bruckner interrupts: "More softly." And again: "still more softly", until the choir gets nervous and keeps absolute silence. But a blissful smile is spreading on Bruckner's face: "*Sehr gut"* very good " - *aber, bitte, wenn möglich noch ein bisschen leiser!"*

Art, in its basic nature, is, like science, striving towards unattainable aims. Therefore neither of them has an end.

Irreconcilable contradiction
The contradiction between the process and the product is the deepest and the most irreconcilable contradiction of both science and art. It is a contradiction between the aim and the possibilities, the unlimited and the limited, the infinite and the finite, and eventually between ethics and the commercial, which in the life of a scientist and an artist often becomes concrete as a conflict with the administration.

I do not know, whether this is an allowable interpretation, but I hear a voice of oppression due to this contradiction in the poem

INCOGNITO

by Otto Manninen[10]. The puzzling abstractness and ultimate condensation of its four verses, where every word and every punctuation mark is loaded full of meaning, have fascinated me ever since our Finnish teacher recited it for our class at the school:

Kuolo taikka voiton palmu! *(Death or the laurel of victory!)*

The internal compulsion of creation is a matter of life or death. Your everything, your whole life is at stake, when your are pursuing the prize of victory of perfection.

- Vastattihin vaivais-almu. *(- The answer was alms for the miserable)*

Humble unto a beggar! Apply for support, grants and stipends. Write schemes and plans. Try to force your infinite aim into the narrow frames of small projects. So, you shall get what you get, if you get.

Otti, kiitti. - Orjan suku! *(Accepted, thanked. - Family of slaves!)*

Well, yes, gratefully you accept the bread of charity rejoicing over every crumb. You are a slave, bit-by-bit worker, whose work has not the justification of continuity and does not deserve the security of ordinary socially acceptable work.

- Vaiko valta, valhepuku? *(- Or power, disguise?)*

But, is it not, that this humiliation touches only the surface? There is a shy conviction, living in one's innermost being, that the of the unattainable perfection is the deepest purpose of life. It is there, in that process of creation, hidden under the beggar robe of shortsighted projects, where the nobility of man, in all its power, force and glory, is lying.

For society and for the administration instituted by it, the pursuit for unattainable ideals is inconceivable absurdity, completely unacceptable daydreaming. The administration, in its position as the representative of

[10] There is no English translation of this poem. Therefore, to give some idea, I can only offer my own and explain as well as I can.

society, is bound to the external ethic, where the responsibility for profit is the core. According to it all work must concentrate on profitable 'useful' projects. However, the internal ethic of science and art, burning in the innermost soul of the scientist and artist as a requirement of perfect truth and beauty, as passion for quality, is an equally strong obligation to the endless pursuit towards the unattainable. Thus, the contradiction between product and process means that the administration is in irreconcilable contradiction with science and art which it ought to control. This is the paradox of the administration of science and art.

The good and the evil

The contradiction between the internal ethic of science and art and the external ethic demanding products is strong. It may happen as for *Sibelius.* I cannot see the termination of his production as extinction of the art in him, but as a result of the ever more compelling fire of the goal of perfection. Since the contradiction between product and process is contradiction between the perfect and the deficient it becomes the conflict between good and evil. When the perfect alone is good, then all deficient is evil. The process aims at the good, but can produce only evil. The internal ethic of *Sibelius'* art made it ultimately impossible for him to carry out that evil, which the incompleteness of the product meant.

This internal ethic of science and art, of all creative activity, is completely irrational and inconceivable for the surrounding society. The society can see just the rational external side of the ethic, concerning products. According to it the good and the evil is in the products, while, from the point of view of the internal ethic, the aim alone is perfect and good and the product is incomplete and, just as such, evil.

The Bible is one of the most basic books of the Western culture. The story of the tree of knowledge of good and evil on its first pages penetrates the core of this problem. We easily think that knowledge, the product of science, is either good or evil. Then we note that good and evil are inseparable - all knowledge is both good and evil. But the Bible does not speak about good and evil knowledge but on knowledge of good and evil. Once I tasted from the tree of knowledge of good and evil, I learnt to know, like God, the good and the evil. Now I know in my innermost heart, in my conscience, what is good and what is evil, and this consciousness is oppressive. Thus, the problem of good and evil is not a problem of product but a problem of the process, of the specifically personal process of every man. It means a persistent compulsion to recognize and choose the values conducting the direction of one's own process. It is an inextinguishable oppression, the oppression of creativity, which I cannot get rid of, responsibility, which I feel unable to bear.

Finally, returning back to the narrow patterns of physics teaching, the idea about good and evil is simplified into the picture about good and poor teaching, which is - as I have explained in the first part of my presentation - largely a picture of process and product and of the conflict between them. For the instructor of physics teachers there remains in this play the role of the Serpent. His task is to tempt the future teacher to taste the apple from the tree of knowledge of good and evil, or of good and poor teaching, and involve him irrevocably in the oppressive conflict between product and process belonging to the teaching of physics. This is what I have been trying to promote, and so, for many, my speech has been the poison of the snake.

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This is the end of my thoughts. As I promised in my invitation, there is now when my thinking has terminated, somewhat more rational poison, i.e. café normal, available for revival of the attendants. For the favor of those who happen not to know the terminology, let me convey what was once said to me by my French friends: coffee without cognac is 'café brutal' and 'café excellent' is cognac without coffee, 'café normal', which I am now welcoming you to enjoy, is of course there between.