DOCUMENTATION OF PROJECT STUDY AFTER 10 YEARS

Karl Hayo Siemsen
University of Applied Sciences Emden / Leer, Germany

Dan Lacrămă
„Tibiscus" University of Timişoara, Romania

Walter Schumacher, Joachim Wiebe
University of Applied Sciences Emden / Leer, Germany

Hayo Siemsen
Institute of Communications Technology and Communications Systems Emden, Germany

Dedicated to Joachim Thiele, who after a century
made the psychophysics of Ernst Mach accessible with extensive and accurate research.

Mental Orthopaedics (Alfred Binet, 1911, 1984, pg. 115)

ABSTRACT: In 2001, in some departments of the former FHOOW in Emden and the HTW in Saarbruecken (Universities of Applied Sciences), a project study was introduced for the first semester [1, 2]. It included a project day per week for one semester. The projects at the FHOOW were for instance LaTeX and PSpice (from a choice of about 15 projects in the field of electrical engineering and computer science as well as projects in the field of Natural Science Engineering / Chemical Engineering, Bioinformatics).[3] The long term impact of the projects within 10 years is reported and each is compared with the experience of a conventional study in the first semester. Dependant on each layout of the *Erkenntnis*-oriented project study at different places and with different familiarities with the concept, different educational intensities are shown. Short time (two hours) and long time influences can be observed to verify if the project study is implemented the right way.
KEYWORDS: projects, *Erkenntnis*-theory, Gestalttheory.

1. DESCRIPTION OF THE PROJECT STUDY

The progress of the projects in the first Semester in electrical engineering and computer science is sufficiently and reproducibly documented in 1, 2. Project studies and conventional studies were carried out side by side without interference during the same semester and faculty by the same teachers: the conventional studies for students of electrical engineering, the *erkenntnis*-oriented project studies for computer scientists. The exams in the basic subjects remained unchanged and were performed by the previous auditors. They were attended by the students of the conventional studies and the project study.

The longitudinal study of the effects of the project study reveals surprising evidence (Fig. 11).

The project study was conducted by professors experienced in conventional teaching, who had with one exception no experience in the project study. Our colleagues at HTW have been trained in a three-day seminar in the procedure. Already in the first 2 weeks displeasure occurred with 10% of students at the HTW (from about 50). This remained constant, and this was about the dropout rate during basic study (the first two years), so at the very beginning. Probably also the overall grades in undergraduate studies were better at the beginning of the project.[4]

Statistical (empirically collected) data are far more reliable to assess the quality of a first semester project study than the annoyance of a small minority of students or a gut feeling among professors to have violated conventional norms. The empirical data are

[1] [SS12] and see footnote 3.
[2] GI_Schussenried, presentation, see footnote 6, Education.
[3] At the HTW Saarland, the project during basic studies in Civil Engineering was "We are building a house" (one day per week).
[4] This observation was made by the dean of the faculty during signing the interims-diplomas. No systematic evaluation has yet been done on this. Also the overall drop-out rate does not seem to have been substantially reduced, only the timing of the termination is now earlier than before the introduction of the project study (in the beginning instead of after two years during the pre-diploma exams). The students thereby lose less time before reorientation. If the drop-out rate in the higher semesters can be brought down by introducing further project elements remains to be explored.

the measure to which this form of teaching is assessed when the standard description cannot be reconciled with the existing situation, i.e. differing significantly. In the area of Science Education, the concepts are unfortunately often determined by evaluations from teachers and students, instead of giving priority to the empirical. As we shall see, the relevant empirical correction (Figures 6 and 7) is used for both →pre-conceptions, the "learning rate" and the "difficulty of the test results". An intuitive understanding of these processes is empirically untenable, at least if the students have collected their intuitive experience under the conditions of →conventional learning. Therefore, special caution is vindicated for these pre-conceptions.

The course in Emden in PSpice was carried out by a colleague inexperienced in project study, but accepting the approach. The course was done over 10 years with more than 200 students; these were the boundary conditions for the project LaTeX. Further project studies in the first half semester were carried out under approximately the same conditions by the colleague experienced in project study. The first two cohorts (years) comprised approximately 50 students per course, divided into different projects. After this time, the president and chancellor changed, who had initially supported the projects. The faculty decided to reduce the proportion of the number of hours in the project study for the first semester, as a whole project day was deemed too much by the majority of the colleagues while too little content was included in the project in proportion.

This changed the objective. The original approach was continued only in the projects LaTeX and PSpice, 2-hours each for more than 10 years. The positive side of this decision is that not only the time-constant for the "turning-on" of *erkenntnis* [5]-oriented project studies became visible, but also the time-constants after the "turning-off". This happy circumstance permits to judge in what time frame a *erkenntnis*-oriented project study is effective and after which time the last signs of this project study disappear (see Figure 11). It is also clear that studies on projects in spite of additional evidence in epistemology no longer than a conventional degree. Furthermore, the images provide the information, at which times with which probability the *erkenntnis*-oriented project study is functional, i.e. the parameters are set correctly.

[5] What is meant here by the German "*Erkenntnis*" is meta-cognition in the sense of knowledge-theory (William James) or epistemology, which includes all ways of cognition, also and especially non-rational and unconscious ways. In the following, "*erkenntnis*" will be used as a technical term, like in *erkenntnis*-oriented (see also [Sie11]). It is a theory of "learning how to learn" most effectively and efficiently.

In the department, among professors, the view prevailed that the students of electrical engineering would have to be "saved" from the *erkenntnis*-oriented project study and its (supposedly) low difficulty level. Therefore, there was in the first two years no mixing of students during the first semester. That changed over time with the two offers PSpice and LaTeX. In particular, the seminar in PSpice proved helpful to many other subjects of electrical engineering. This was quickly recognized by the students.

After 2 years and in the 6 years following, the project study showed effects: the former students of the project study in the first semester (all students of computer science) and their tutors published 68 articles[6] under review, including 12 doctoral dissertations, a total of more than 4500 pages under review (see Figure 11). The internal diploma theses [7] and theses in companies are not included in Figure 11. Diploma theses with a colleague of high-frequency technology, who got involved a year later in the project study are shown in Figure 12 and show a similar course with a one-year delay.

The approach should be analyzed in its educational function and explained thereby, how university operations can be optimized under which changed conditions and without additional cost. The not-active learning components are removed and the time is reused for a focus on the learning-effective parts. The parts effective for learning are thereby highlighted dramatically.

2. AN EPISTEMOLOGICAL, PHYSICAL AND PHYSIOLOGICAL GESTALT STRUCTURED PROJECT STUDY

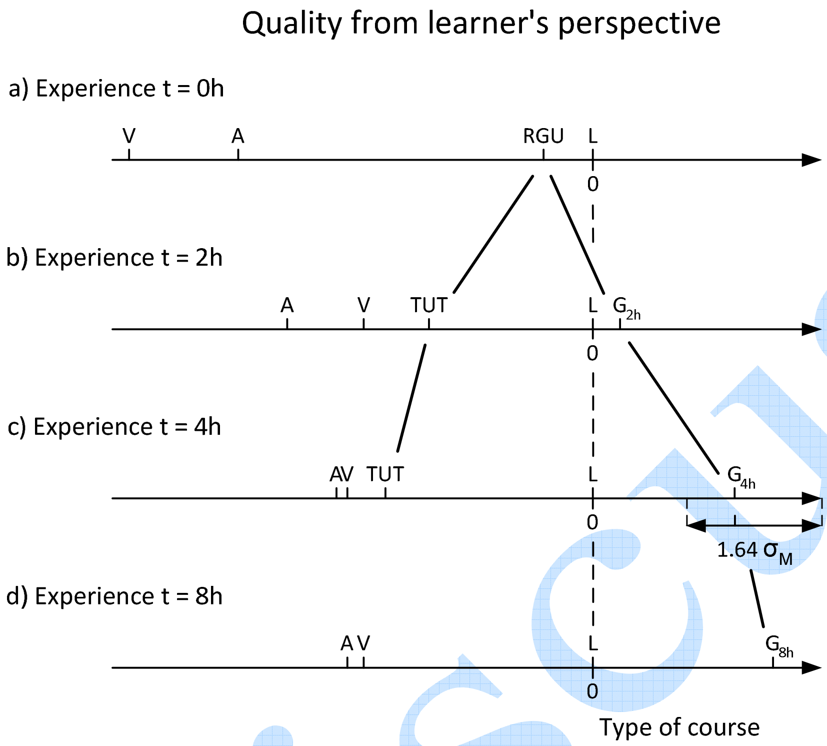
How does one arrive at such a project study? The background is a PhD thesis at the University of Heidelberg from 1980 ([Sie81]). The empirical data were collected at the Technical University of Karlsruhe from 1971 to 1975. They are compared with current data from PISA ([OEC07]). Historical data regarding this approach from 1859 [8] onwards have been compiled in the years after 2000 and made compatible with the empirical data. From this experience, the *erkenntnis*-oriented project study

[6] Hochschule Emden/Leer -> Publikationen -> Siemsen

[7] Former German system comparable to Master theses, though slightly shorter in its time frame. The diploma-thesis took three months to half a year.

[8] The date of publication of the "Origin" by Charles Darwin. This event and the following analysis by Mach (Mach in 1909, 1888, 1863, 1890, 1906 (in Binet's journal)) on what are the consequences of a theory of evolution for humans and human knowledge, began to approach the "genesis", which is used here as a metaphysical and empirical basic element.

was designed. Basis of the draft was the optimal taken from the previous empirical experience together with a combination of the theoretical foundation from the history of science. The president of the University of Applied Sciences Emden / Leer aptly described the approach as a way to provide the University with a new and promising goal.



Legend: L = regular lecture, G = genetic small-group teaching, A = audio-visual presentation, TUT = tutorial (without *erkenntnis*-oriented training of the tutors), L = laboratory test (example: physics laboratory), RGU = computer supported teaching, σ_M = spread from the mean, h = number of hours

Figure 1: Performance of forms of teaching from the perspective of the learner

In Figure 1, the →assessment [9] of students, their →expectations for this way of teaching their →experience with various forms of teaching was requested. As a measure of their judgment the →laboratory test is taken, for instance from a →Physics Laboratory with solid experiments, well worked out, to which they can prepare themselves by a →test instruction for each experiment, typical of technical physics study in the lower semesters. Before each test, they were interviewed by an assistant in groups of 3 to 5 persons in order to recognize the state of preparation. Then they work through the tasks set for them and answering the questions from the instruction. The assistant verifies that they take the path provided in the instructions. This form of teaching is valued by students and is a good benchmark to compare other forms with. A lecture, for example, is assessed significantly worse in its learning effectiveness, tutorial courses not much better, an audiovisual lecture (at the machine, i.e. machine or film) even worse. This assessment is stable over time.

The *erkenntnis*-oriented project study in small groups with the assistance of a computer is first evaluated skeptical by the students in comparison to the laboratory experiment. This attitude disappears with increasing experience of this instruction from 2 over 4 to 8 hours. The distance from the lecture to the lab experiment is comparable to the distance from the lab experiment to the *erkenntnis*-oriented gestalt-psychological (abbreviated "genetic") project study. One can see a pair of scissors in which well-known courses and genetic project study are evaluated further and further apart with growing teaching experience. Since the genetic course - as will be shown - is underestimated considerably in the two main points of learning speed and difficulty of the tasks, the gap is actually widened further than indicated by Figure 1, i.e. by the view of the learners. The gap between laboratory experiments and genetic education is therefore larger than what the students express. Figure 1 also shows that the introduction of student tutors without former gestalt psychological and *erkenntnis*-oriented training does not bring the success that one might hope for ([Sie81]).

---

[9] → reference to the Glossary presented at the end of the [SS12] paper

These scissors have been chosen as the starting point for the investigation to improve Science Education from the perspective of the learners. It is consistent with historical epistemological considerations, especially those of Ernst Mach ([Mac75, Mac92, Mac97, Mac00, Mac01, Mac10]).

With the *erkenntnis*-oriented project study in the 1st semester, the experience of students is at least 30 h compared to 8 h in the study 1972 - 1975. The estimates after this period could unfortunately not be measured separately. The later statements of the students provide no reasons though to assume the subsequent course of the scissors differently.

The crucial point in the argument will be to describe the genetic teaching in such detail, that it is reproducible without creating significantly additional costs. These would ultimately express themselves in personnel costs, but such costs were not observable in the one-man operation of the project study.

3. GENETIC LEARNING FROM DIFFERENT PERSPECTIVES

Genetic characteristics of teaching from the perspective of the learner

The categories under which students see a genetic lesson are:

- The thoroughness with which they "worked into the fabric" of the lesson, internalize it
- The concentration that they apply in this way of learning
- The pre-conceptions that they form in themselves
- The pressure to perform, which they want or which they feel
- The speed with which they believe to learn (or the superficiality)
- The difficulty of the contents of the topic, or specifically of the task

These categories are a reflection of the experience of students, the "metaphysics of the curriculum". They are not independent of each other. Thoroughness and speed appear to be antagonists. Pressure to perform can inspire or disturb. Concepts that do not (yet) reflect the exact facts might be considered superfluous. A "difficult" topic does not appear to be adequately reflected by easy tasks, but shows its difficulty through difficult tasks. These categories are actually effective, but reflect the process of learning as a theoretical construction rather than an empirical scientific view.

Therefore, it is essential to augment these categories through the aid of empirical evaluations with other theoretical constructs, pre-conceptions that do not carry these contradictions. From this follows the view into the history of science education and gestalt psychology, in particular to its pioneers. These include Comenius, Pestalozzi, Froebel, Mach, Ostwald, Binet, William James, Dewey, Wittenberg, Freudenthal, Snellman, Cygnaeus, Eino Kaila, Nevanlinna, Ahlfors, C. Buehler, Wertheimer, Luchins, Goldstein and others. They have wrestled throughout their lives with the concepts, in order to describe the learning in science and technology academia. They have wrestled with the metaphysics of concepts, without getting caught in contradictions to the empirical facts or in avoidable circular arguments. But first to the categories, which solidified in the minds of the students, with which they analyze learning, to the metaphysics of the curriculum from a student perspective.

Between the *erkenntnis*-oriented project study and the genetic adaptative [10] lessons are 35 years in which students were closely observed. This resulted in additions, such as the increased use of psychophysics, accentuations and experiences as well as a historically founded theory. The starting point of this theory was then and is today Ernst Mach (noting that it is now much easier to investigate cost-effectively the sources that he has left, see [Thi64, Thi66, Mac13]).

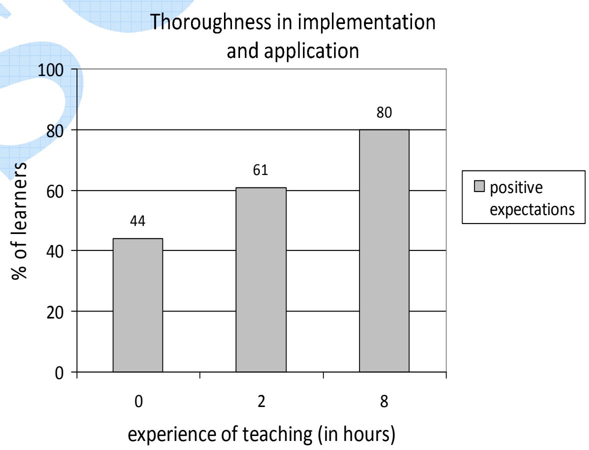


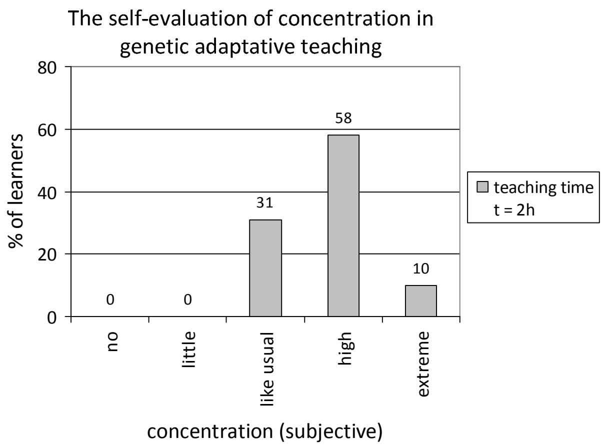
Figure 2: The expectation on the thoroughness of learning to a genetic adaptative instruction

Figure 2 shows that 80% of the students keep after 8 hours of teaching experience for a genetic instruction thoroughly. The saturation value should still be slightly higher. We are thus dealing with a form of instruction, thoroughness in the foreground.

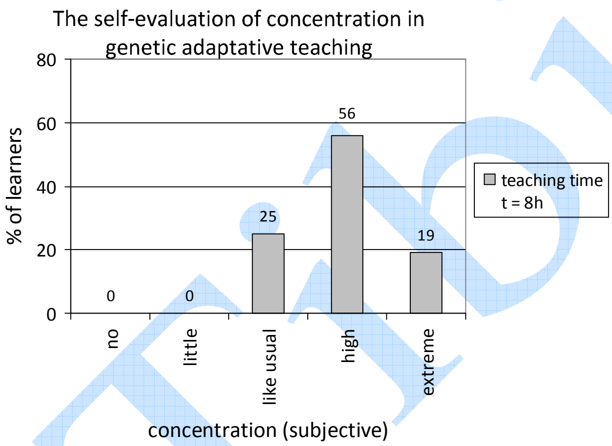
Even for concentration, it looks as if the students are involved more than usual (probably in comparison to the lecture, Fig. 3a, 3b). Again, after 8 hours there

[10] Adaptatation means (short time) interaction (reciprocal tie) between human and the environment (Mach, Piaget, Newton, James). This is contrasted to an adaptive, i.e. one-sided action. Here a more general understanding of evolution is taken than the one used by Charles Darwin (based on Lamarck, Spencer, Wallace, Mendel, Goldstein, Erasmus and Charles Darwin).

are almost 80%, which feel that they are very or extremely concentrated, so that little or nothing escapes their attention. They are exhausted after 2 hours of continuous genetic instruction and must - comparable to having watched an exciting movie - return to →reality. If, after 80 minutes, they were asked how much time had passed and they wear no watch, they appreciate the time with typical values of 20 to 40 minutes, in no case more than 80 minutes. In their experience, time flies in contrast to a typical lecture, in which the clock in the classroom does not seem that it wants to move at all.



a.



b.

Figure 3a, b: The self-assessment of the concentration of students in classes according to different genetic adaptative teaching experience of 2 or 8 hours

Again with 80%, the saturation value for learning under →concentration is not reached. The current understanding of the world (see Figure 4), which previously seemed tediously constructed but consistent, now needs to be reassembled. The integration of new or fundamental pre-conceptions into the current understanding of the world *enforces* this concentration in the learners themselves. No apparent pressure is applied from the outside during this process (cf. Figure 5). In the adaptative interaction, the "self" becomes irrelevant for a limited time-frame.

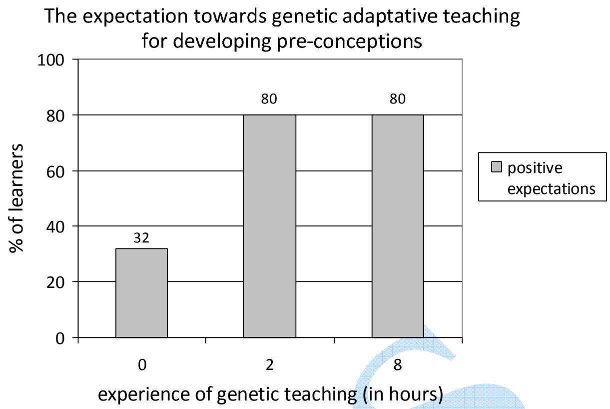


Figure 4: The expectation towards genetic adaptative lessons, in learning to develop pre-conceptions

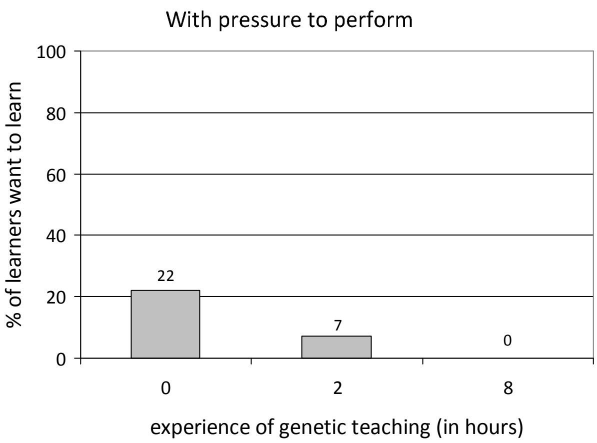
A genetic instruction is also characterized in that the students learn from this lesson how to develop →pre-conceptions from it (see Figure 4). [11] This is clearly perceived by them after 2 hours of teaching experience. This explains the strong theoretical links of the lessons to →*erkenntnis*-theory, →Gestalt psychology, →physiology (perception through the senses), →physio- and →psychophysics. The pre-conceptions that the learner develops form the basis for a →worldview that gradually builds up and is refined. If other, different pre-conceptions for learners are already in place, the expectations are irritated and the pre-conceptions have to be consistently applied (perhaps completely new). At least in this case completely new pre-conceptions are offered. In a genetic instruction, *the learners themselves have to construct* how he or she incorporates the pre-conception logically unobjectionable into his or her previous thoughts. A genetic lesson will stop at each such point in the concept and offer discussion. The teacher has to grant this time to the learner.

It may seem strange, but in a genetic instruction, students learn without pressure (Figure 5a, 5b). The longer their experience continues in this regard, they also want to experience this. Genetic lessons therefore are largely free of fear, and this with at high concentration. The learning goal "*per aspera ad astra*" is not valid, there is no "cramming" of contents. [12] The gestalts are "sucked-in like mother's

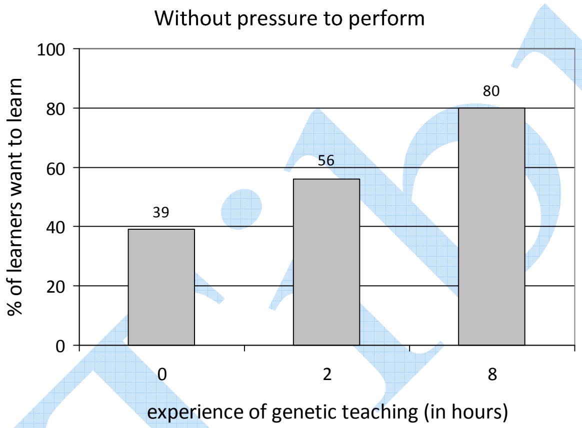
[11] i.e. what the classic lesson does not seem to demand from them.

[12] Rather, like the introduction of Ovid's Metamorphoses, "*Aurea prima sata est aetas, quae vindice nullo, sponte sua, sine lege fidem rectumque colebat. Poena metusque aberant nec verba minantia...*" (This was the Golden Age that, without coercion, without laws, spontaneously nurtured the good and the true. There was no fear or punishment: there were no threatening words to be read, ...).

milk" (Einstein, in his obituary on Mach's influence), not drilled-in or trained by dressage. Everything must be understood on its own, classified by the learners. Any threats are undesirable, and yet no learner switches-off (Fig. 4). This is reminiscent of Froebel games, so the interaction of high concentration and the more leisure-oriented game. Strategies of teachers of exerting pressure with whatever means are undesirable and interfere with a genetic instruction in the early phase. This also implies that →personal power issues are largely excluded.



a.



b.

Figure 5a, b: learning with / without pressure to perform in a genetic adaptative instruction

Figure 6 gives with growing experience the impression that genetic learning is slow, would cost a lot of time (because it is thorough, see Figure 2), that it requires a lot of time to learn properly. This is an argument that requires further empirical and theoretical analysis. It will be shown later that it is a drastic →perceptual illusion of the learner. The model that the students (from the past, from their experience) have in mind is a →linear learning model that leads to this error. There are many indications that genetic learning has an exponential character, i.e. relative to the linear model, it first runs *seemingly* slower (and shockingly "easy" as some of the professors have expressed it), then to become almost explosively "fast". Take for instance the total time, which the students needed for reaching a PhD (see Figure 11). In spite of having studied in a genetic way, they achieve this common objective in an amazingly short time. One also finds a thoroughness not reached with other teaching methods (Fig. 2), essential for a scientific approach, and thus the first step towards the doctoral dissertations.

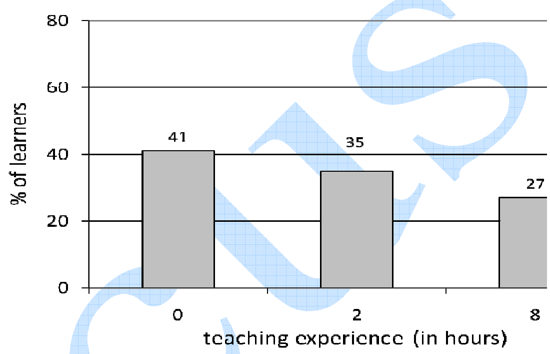


Figure 6: The expectation of the learner to himself in genetic adaptative lessons to learn quickly

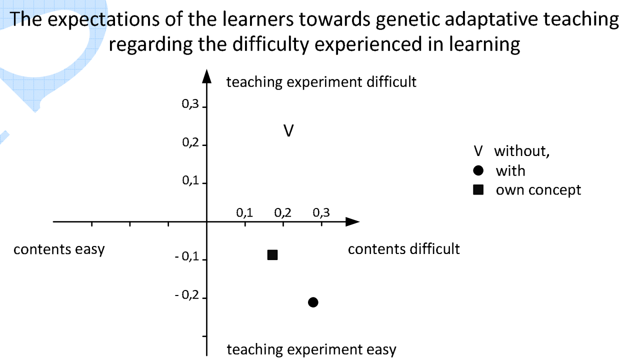


Figure 7: The expectation of students on genetic adaptative instruction regarding the difficulties that they feel in learning, one based on the content, even on the teaching experiment itself

In Figure 7, the expectation of the students about the difficulty of experiment and contents before the genetic instruction (**V,** so no experience with that learning) and their assessment of these problems after such instruction (i.e. with experience in genetic learning) are assessed (●). The students were also asked about their view on how an optimal problem difficulty should be designed in order to enable learning (■). At the center of Figure 7 lies a →moderately difficult content for a →moderately difficult experiment. The estimates of the learners can thus be understood, as if in their consciousness - as subjective assessment - the difficulty of the content remains almost constant, at least in a first approximation. The teaching experiment, however, which is more difficult on first sight, proves after the genetic learning process on closer inspection easier than initially suspected. It is - probably in order not to avoid the trouble of learning, but to "bravely" face the task - wished to again become more difficult.

A content that is mastered, *seems* to be easy [14]. This fact has not yet been understood by the students. Even after a semester, they do not →trust it. Therefore, the estimate of the experiment by the students is a →perceptual illusion. In the procedure described also lies the key to the →cultural embedding[15]. The problem of →integrating students coming from other cultures or from families of lower class is hereby solved. No one is left alone with his or her (perhaps at first not matching to the scientifically requested) pre-conceptions. The learner gets all the necessary support and time to build up the basic pre-conceptions without contradictions.

The students perceive the tasks of a genetic project study as much easier than initially expected (Fig. 7). They value the content of the discipline as a pretty difficult (and want some more challenging tasks for it), the latter, however, would contradict the claim of genetic instruction, namely to learn developing pre-conceptions in terms of Gestalt psychology (see Figure 4). Following this student assessment in the course over several years and a possible change over that time will not be pursued here. There is no evidence that lessons with difficult tasks would be faster, on the contrary. If parts of the genesis are omitted, this has endless dramatic consequences in the lack of understanding of all concepts based thereon. Any mistake in teaching is thus metastasized. Trying to learn faster by omitting parts of the genetic process will fail, as well as trying to increase the difficulty of the task. This applies to teachers and learners.

Annex 1 depicts an example of a genetic lesson in Science Education.

4. GENETIC LESSONS FROM THE PERSPECTIVE OF THE TUTORS AND ASSISTANTS

This group has benefited from the project study. They have contributed to publications to a much greater extent and have partly they done a PhD during that time.

5. LUCHINS AND HIS COLLEAGUES - THE STORY OF HIS DISSERTATION

This is the story of the dissertation of Abraham Luchins, the student of Wertheimer ([Luc93], p2). The behavior described for one of his supervisors is similar to that of some professors at the FHOOW and seems to be typical of the criticism voiced towards genetic adaptative teaching methods.

The thesis of Luchins was filed at New York University on "Einstellung - effect of learning by repetition." At the suggestion of the supervisor of the thesis, Luchins presented his draft in front of the graduates committee. The committee expected additional historical work in psychophysics (using the terminology from Mach) and judgment scales. A statistical analysis was supposed to demonstrate the critical ratios for each difference.

After finalization, a member of the committee claimed that it was impossible to get such large critical ratios. Therefore, "there must be something wrong with the research". The large impact needed to be due to an uncontrolled variable. Luchins agreed to repeat his experiment in the presence of the critic in a class of his choice. The critic himself could score and tabulate the responses.

Luchins repeated the experiment successfully with the same results. Nevertheless, the puzzled member of the commission renewed his claim that there must exist an uncontrolled variable. He claimed that when he himself did the experiment in his class, it gave different results. Luchins pointed out that the actual method used by the critic differed from his in important aspects. An experienced statistician in the

[14] This is also the trouble of teachers who have mastered a content to see, what is easy and what is difficult for students as for him or her, all seems easy. Many teachers thus teach in order to show that they have mastered a content and not to optimize learning for students who are novices in it (see [Mac90]).

[15] Also, the project is not culturally specific. In the Czech Republic (Brno), a similar attempt was made from a doctoral student in physics in a course he gave on astrophysics. In the course, the students should independently organize a simulated scientific conference. The results here were that 1. the understanding of the subject was significantly better for all participants; 2. now more students could be classified as "very good" including some which had seemed "very poor" in their performance before; 3. afterwards, everyone was more motivated to study their subject and 4. students also acquired additional skills, for which otherwise there would not have been the time to teach them. Similar effects of genetic teaching can be observed in other countries as well (e.g. Finland, Switzerland, France, Austria, India, Russia).

commission then noted that one necessarily gets large numbers when weighing an elephant with gram weights. Subsequently, the thesis was finally accepted.

6. THEORETICAL FOUNDATIONS OF A GENETIC INSTRUCTION

A crucial point for a reshaping of learning lies in installing a genetic process at an early step of the learning process and resting at this place, until the basic pre-conceptions are built and stable. The incorporation of an adaptative genesis guarantees largely similar cultural, gestalt psychological and psychophysical preconditions required for a content after passing through the learning genesis. After the genesis concerned with the basic concepts, principles and pre-conceptions had run its course, the following more content-related learning processes become largely independent of culture. They are consequences of learning the basic concepts and turn out as the obviously easier part of learning [16]. Thereby, the learners can easily learn them to a larger degree by themselves. The lecturing of contents by professors at universities is not required in the dimensions currently practiced. It is too much time invested in teaching into an area, which generates little benefit and has diminishing marginal returns, i.e. the more one invests, the fewer (relative for every coin invested) the benefit. Some things can be optimized, but rarely bring overall increases of more than 5-10% in efficiency or effectiveness. From the zero-sum game of the maximum usable time of the learner [17] and the teacher follows that their time can be used elsewhere far more effectively.
The conclusions from the basic concepts need not be presented in lectures by professors with painstaking effort and impressive drawings on black- or whiteboards. You can easily read about it with often better quality in books, for example. A lot of time is wasted in talking, as after a genesis, the learner can teach it to himself much more effectively. Many of the students who are classified in the linear learning model as "average" or "bad", show their potential in a genesis and an *erkenntnis*-theoretical seminar and will develop a non-contradictory model of thinking in self-study and project study.
In principle, one can speak of a →metaphysics of the curriculum and a typical Machian approach. This means avoiding auxiliary constructs [18] carried over from the past as habits, as long as what they describe does not constitute curriculum. One has to reduce the metaphysics of the curriculum to the necessary, empirically reproducible part. Evaluation agencies and the department often rely on gut feelings and concepts in education that empirically have proven to be fictions. These fictions are not tenable in science. They hide within them costs of greater magnitude.
Before details on genesis are discussed, a further objection, which seemingly speaks against the installation of a genesis. Genesis is nowhere to be found in the curriculum. Therefore it goes beyond the limits assigned to the teacher by the curriculum and the assessment of an evaluation agency. Is the teacher entitled to this kind of digressions? Regarding this, there are different opinions concerning the freedom of teaching, which is enshrined in the Basic Law in Germany (*Grundgesetz*, which is the German form of a constitution). The teacher teaches content (of Gestalt psychology as applied to Science Education), which according to the conventional view is not part of the curriculum (e.g. physics). That makes him *de facto* vulnerable to attacks. The opposing view is that this does not concern others or the department, because of the freedom of teaching. The teacher has good empirical-statistical reason to develop his approach this way. The Basic Law allows him not to defend his actions against third parties, but to simply apply them. Attempts to prevent a genetic approach by the duty of organization of the department are prohibited. Apart from this, the learners can learn seemingly much better and faster and with significantly fewer side effects. Considered empirically, there is no doubt about that. It is time to free the theory of the curriculum of the parts of metaphysics which have no business to be there.
The relative proportion of the *erkenntnis*-theoretical, cultural, Gestalt psychological or physiophysical components in the genesis is not given. It depends on the subculture in which the learner grows up. If, for example, the eye movements of the learner are ignored in the learning of reading in elementary school, a large proportion of students with dyslexia are produced in elementary school. The evidence of gaps between words and similar conventions are not observed by these elementary school students, the eye movements of the students are not affected by them. In the example, the proportion of physiophysics rises (control of eye movements), which needs to be spend on learning to read and write. Should one ignore that the student may spend 12 or 13 years in school and 4 years at university

[16] Thus, learning is more accessible to a statistical analysis.
[17] The effectiveness of improving the learner/teacher ration thus also has its clear limits.
[18] This does not speak against auxiliary constructs, but against their unreflected usage. If many old constructs can be replaced by a new construct (as in the case of gestalt for instance), this might actually be thought-economical.

without this defect being noticed or ameliorated. The student receives no help. Such repairs need - depending on the case - between 3 days up to 6 weeks, 2 hours a day, depending on how much the learner can exercise self-control. The time for this repair is out of proportion relative to the ridicule from students and professors, to which the reader has been subjected for nearly two decades without fault and which affected his self-esteem dramatically.

From the statistical data from PISA 2006 (Table 1) shows that it is extremely worthwhile, to work on the epistemological, cultural, Gestalt psychology and physiophysical deficits of the learner [19], especially the laggards (see Table 1b, Finland in the field up to level 2). This results in yielding up to four times the number of top people in the area of Level 5 and 6, compared to the opposite approach (OECD average). The opposite approach often means to encourage just the learners at the top of the control group (right branch of the normal distribution) by a so-called "Excellence Initiative".

The normal distribution of the OECD is already dramatically inferior in yield relative to the Finnish distribution, where the laggards have been retrained with a genesis that had been apparently missing. In other words, the linear model of excellence initiatives leads in a country like Germany to an annual investment of funds of several billions of Euros without any significant yield of excellence (maybe the few students have become slightly better, but they have not become more). Maybe such an approach was still feasible at a time, when only few highly skilled people were needed in a society, but in times of a severe lack of skills, it is doubly wasteful. The investment into the right branch of the normal distribution results in little appreciable success [20], because of the small number of subjects. While in contrast the concentration on the laggards and eliminating the causes of the lagging needs no additional money and achieves four times the yield of learners at the top.

Compare the two surfaces of the left branches of the distribution curve for the U.S. (marked dark gray in Table 1a) and Finland (light shading in Table 1b). One can see immediately that in Finland the problem of laggards is being addressed. Then compare the two faces of the right branches of the distribution curve for the U.S. (marked dark gray in Table 1a) or Germany and Finland (light shading in Table 1b). The top performances in the U.S. are modest compared with those of Finland ([Sie12b]). The area under the right branch of the curve in the U.S. marks the yield of excellence, when the laggards are not encouraged, the area under the right branch in Finland marks the much higher yield of excellence for the example of Finland in comparison with the U.S. (for a comparable task). The statistics will not tell if in Finland the initial laggards remain relatively at the lower end of the scale [21]. One may well find as a result of Gestalt psychology training that they become part of the excellent students.[22] This will require further investigation.

---

[19] This is since long time common education practice with special needs pupils for long time.

[20] Especially if taken into account those included with an eidetic memory are included among the "top" students.

The results in mathematics and in the latest PISA study are not fundamentally different, particularly with regard to Finland curve. In relation to the basic perspectives on science and mathematics education examined in this article, strong short-term changes are not to be expected. The Finns needed about a decade to train a significant number of teachers (and several decades before to develop the method, see [Sie11]). A significant part of the short-term changes is therefore likely due to "cosmetics". The understanding of the students in mathematics and science is thus not fundamentally changed. It remains "untouched" so to speak regarding the *erkenntnis*-processes.

[21] The reworking of the laggards is based - at least on the investigations Figure 8 and Figures 9 and 10 - the simplifying assumption that the problems can be fixed within 6 weeks with a maximum effort of one hour daily. Regarding the students this is usually the case. More serious problems - as observed by psychiatrists in a general population - remain unresolved within the given monetary frame.

[22] If one works on the problem of laggards and resolves their weaknesses by education, also in Finland it can be observed that these latecomers often do not end up back at the lower end of the scale, just shifted to higher scores, but can "jump" into the top group passing other students (e-mail from Kaarle Kurki-Suonio 05.05.2012 referring amongst others to the teacher Katja Palomäki. She told: "…being pupils of marks 5 [worst grade], is not due to being stupid. But the pupils of our school have a lot of problems in their homes. …. But then there are a few such pupils, who have thought that they are stupid, but I have succeeded in encouraging them to pose questions. And it has turned out that they make excellent questions showing that they have really understood what it is about. So, there is hidden potential in those pupils once they could be made to work for their studies …").

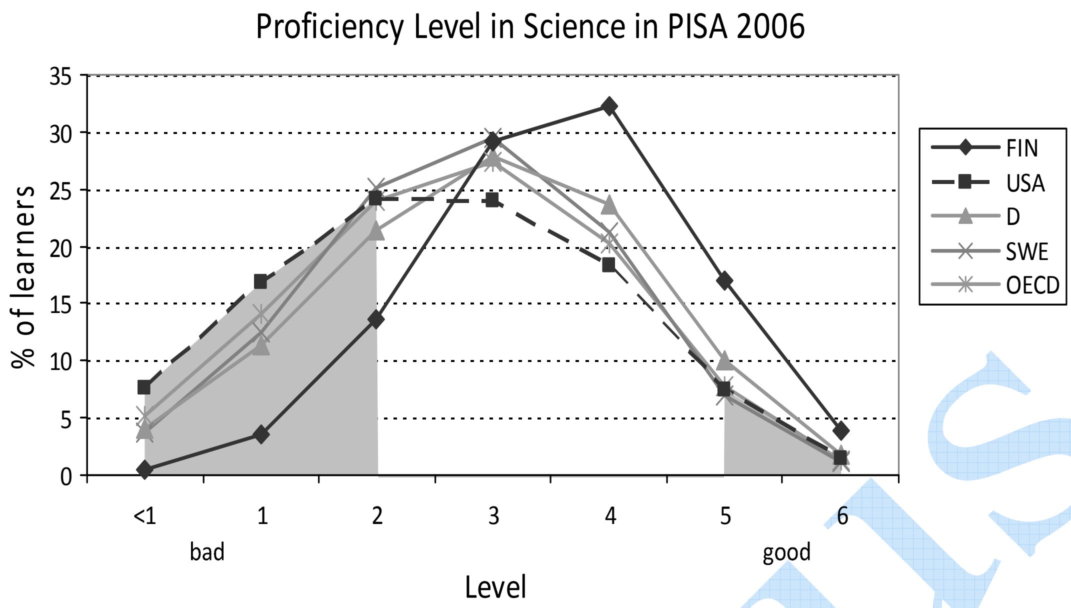


Table 1a: Distribution of "grades" in PISA for the United States ("6" is the highest grade, more than 708 of 1000 points, [Sie12b])

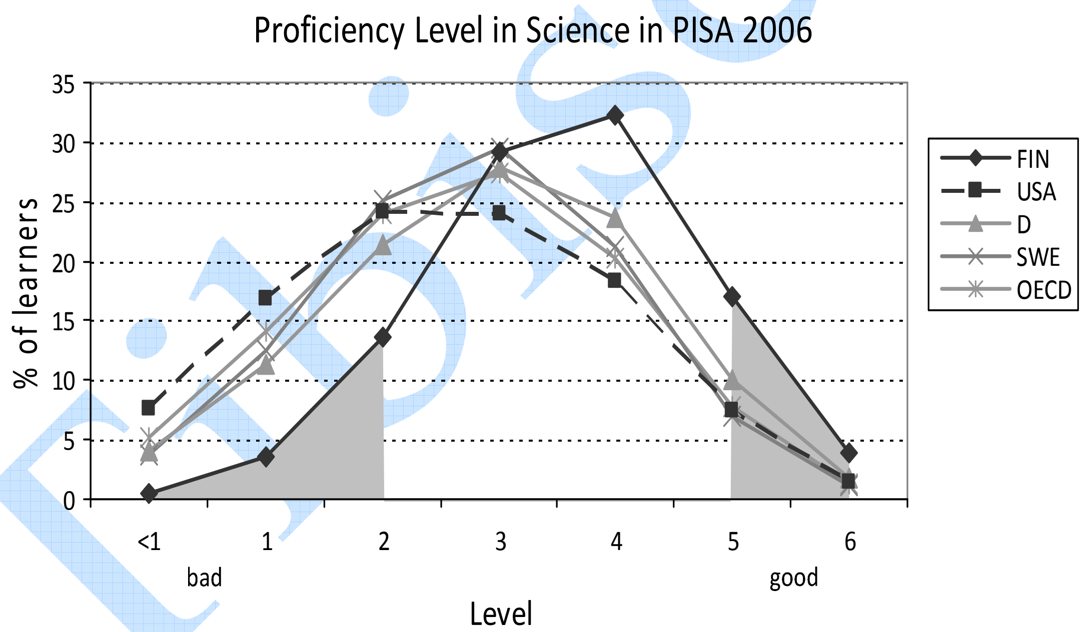


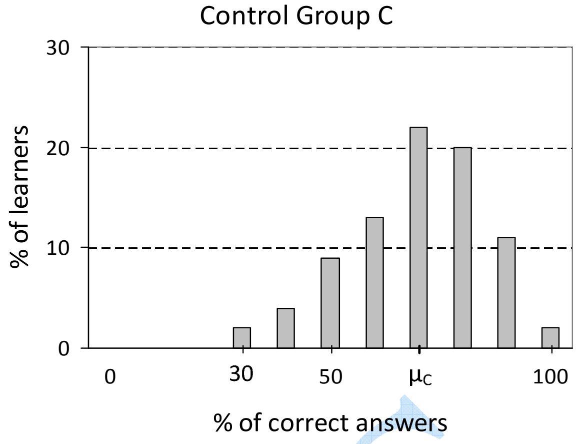
Table 1b: Distribution of "grades" for PISA in Finland (FIN, "6" is the highest grade, more than 708 of 1000 points) Source: OECD ([OECD07])[23]

[23] The results of PISA 2006 (published 2007) were taken as an example, since here PISA tested "science" for the first time. More recent PISA comparisons do not lead to any fundamentally different result regarding Finland, but show more "habituation effects". Individual countries increasingly seek specific one-off measures, which can be brought about for instance by a PISA test drill, or by recommending the potentially poorly achieving students to remain home on test day.

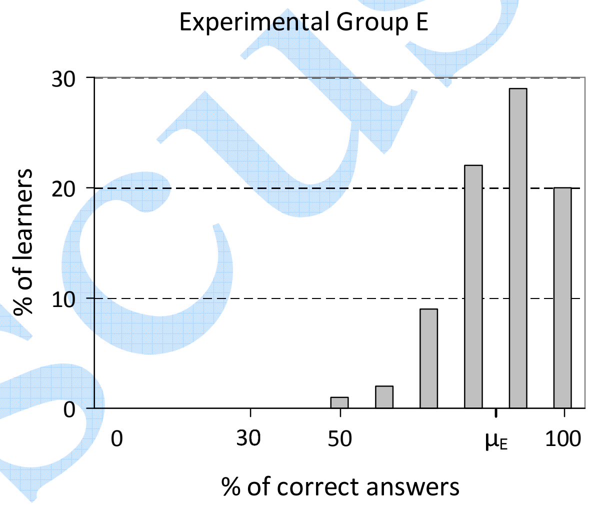
A similar, under laboratory conditions much more accentuated picture relative to the data from PISA, Table 1b. The former FIN right branch of the curve results from the empirical data of the genetic adaptative learning (Figure 8b). C means control group without, E experimental group with genetic teaching from a single cohort, evaluated after the lesson. The mean values are indicated by μ, the standard deviations σ. On "easy task", see the notes on the assessment of students regarding "light" and "difficult" tasks in Figure 7. It is obviously desirable to make tasks easy (and in a genetic instruction it can probably not be "prevented" to do so). This is achieved by gestalts, i.e. useful pre-conceptions onto which the learner can construct his or her worldview (i.e. by no means irrelevant "light" problem settings). At the same time one must make sure that the learners do not underestimate the now hidden, but still existing difficulty of the content and as a result should be led to the fatal idea of stopping their own learning altogether (see Figure 3).

The control group in Figure 8a shows an approximate normal distribution, similar to the graph of the OECD averages in Table 1. The students of the top group (90 - 100%) of the control group are also in this case significantly less in number compared to the experimental group after the genetic, more Gestalt psychological learning (the two bars in Figure 8b at 90% and 100% are much larger than the in Figure 8a at the same x-coordinate position). Figure 8b also shows the dramatic influence on the more Gestalt psychological learning (the two bars in Figure 8b at 90% and 100% are much larger than the in Figure 8a at the same x-coordinate position). Figure 8b also shows the dramatic influence on the genesis of the laggards, the bars at 30% to 60% in Figure 8b in comparison to the bars of 30% - 60% in Figure 8a. (The bars at 30% and 40% have disappeared in Figure 8b, students as laggards no longer exist in the experimental group).

A similar picture already emerges from the project in the 1st semester ([SS01a], see Figure 9 and Figure 10), only the consequences regarding later years were only fragmentarily known at the time of measurement:



a.



b.

Figure 8a, b: Typical distribution of the frequencies of learning of the investigated sample regarding their performance ([Sie81]) for tasks valued as "light" and the same task, compared to the control group (C) - compared to the experimental group (E), the latter in a genetic adaptative teaching

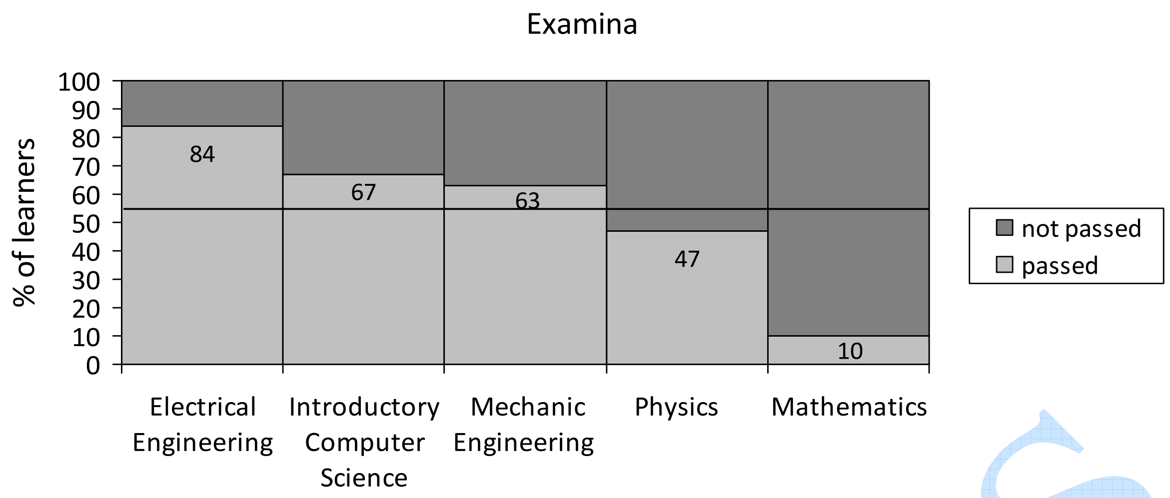


Figure 9: Successful (light gray) and Fallen (dark gray) in the control group students in basic subjects. The value of mathematics is estimated

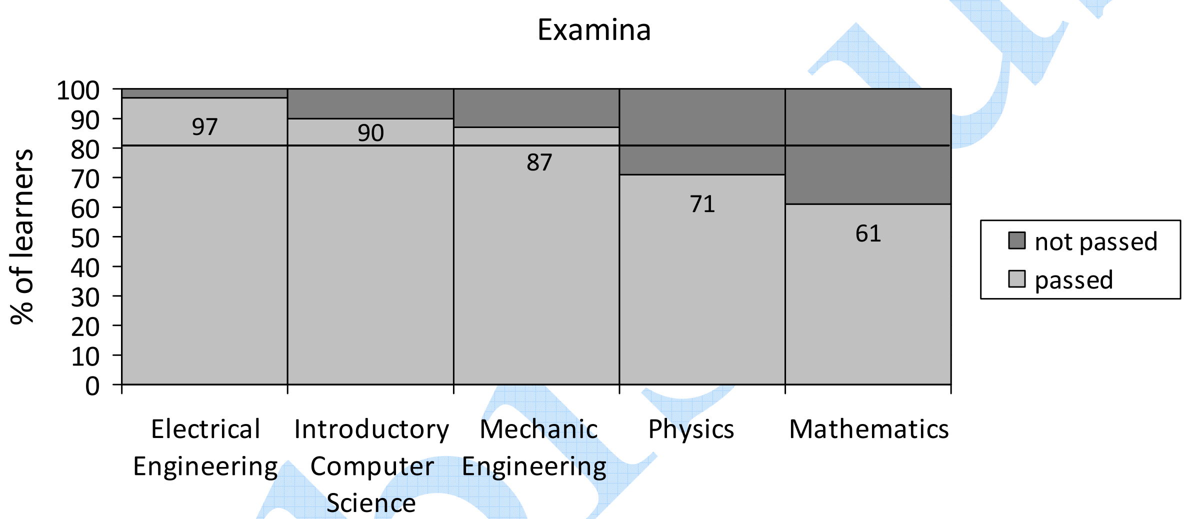


Figure 10: Successful (light gray) and failed (dark gray) exams of students of the project study in the same basic subjects

Here are two Figures 9 and 10 in comparison. The mean value of passing the tests of the control group lies at 54%, of the experimental group 81% (same examiner, largely the same tasks, same exams; the students in the control group, the electrical engineers, were previously evaluated by the professors as the better students). The failures are marked in dark gray and for the control group already show a clear warning in view of further study. The proportion of "dark gray" in the control group (Fig. 9) is significantly higher than in the experimental group (in this case, the students of computer science, Figure 10). It is striking that the experimental group with its *erkenntnis*-oriented project studies obtained better testing results in areas, where the project content is not immediately recognizable. Is it a "transfer" as a result of applying methods of *erkenntnis*? The professors (even skeptical) of civil engineering at the HTW believe to observe a transfer from the project study on all subjects of the study without our influence (though not on the long-term grades and probably not in the example shown in Figure 9 and 10 degree). Similar results can be shown for PSpice (see below). Figure 10 gives a strong indication for this view that needs to be further studied, however, distinguishing according to conceptual and methodical influence of *erkenntnis*-oriented project study.

Already at an early time, after the 1st semester, one can observe that the students drawn from the same cohort - the weaker in the opinion of the majority of the professors - have been improved in the experimental group and moved into the top group. For the control group, this improvement obviously does not take place. The "protection" that was intended to be given to the students of electrical engineering has failed from an empirical point of view. Continuing to work with the control group (in a conventional study there is usually no experimental group), is unfortunately common practice, but an unproductive and unnecessarily costly one. It should not come to that!

Further working with the control group is based on a linear model of learning. The conceptual linearization with promoting a small currently leading group and waiving the process of genesis is expensive (the learning at best reaches a tiny minority, and even they could have been previously promoted by parents [26] or previous teachers). It is mostly covered by the repercussions of the follow-up problems from the lack of *erkenntnis*-theoretical, cultural, gestalt psychological and physiophysical assistance (resulting in a dramatic extension of study time). Viewed empirically, it is, as compared to the approach of an *erkenntnis*-oriented project study shown here, extremely unproductive.

After the end of the semester in the following cycle, a separate seminar on mathematics was offered, apparently a kind of "problem child" (see Figures 9 and 10). The students were told regarding the participation in the seminar that who will attend regularly, will very likely pass. Three of the initially 12 participants have participated to the end and consequently passed the mathematics exam on their own. Unfortunately, the number of participants is not sufficient for a statistical evaluation. (As 61% of participants in the project study had already passed the mathematics exam in the first semester, there were only a maximum of 20 voluntary participants available, the actual drop-outs (10% of 50) also needing to be removed; Also one could observe in the 12 participants - at least 9 of them - significant deficiencies in time management[27], although the seminar was offered in a way that it did not collide with the second semester.) The (unique) effort to prepare the seminar for mathematics for teachers was considerable (15 weeks, 4 hours per week preparation for the analysis of typical perceptions and culturally acceptable gestalts in the problems used in the course, which involved two professors and two tutors) additional to the seminar itself. The effort to support three regular participants with not feasible and would have needed to be integrated into the exercises of Advanced Mathematics. In the second run, the resources for this were not available anymore.[28] Therefore, the consent of the colleagues, with whose exercises one would have needed to interfere, was not sought. Here we find a position which could not be optimized to the desirable extent due to boundary conditions. To a lesser extent this also applies to the subject of physics.

For most students, the acquisition of culturally more appropriate gestalts in most subjects has apparently run smoothly. This explicitly includes →students with foreign roots and the students who are culturally disadvantaged due to their parental background. Because of the thoroughness (Fig. 2) and care in the procedure, integration is not a subject for lengthy investigations in this kind of teaching. However, about 20% of the students are not satisfied with this type of learning. Half of these students will fail to study, others may choose different approaches of learning. These two groups were not further investigated. It is not easy to sieve them out from the 80% content during the semester.

With this restriction, it seems worthwhile to investigate the consequence of Figure 1, the quality of the learning from the perspective of learners. These empirical data are also indicative of Figure 6, the impression that learning would run more slowly, because being more thorough. The control and the experimental group learned in exactly the same time, with the genetic learning, despite the time invested in it for other goals, obviously achieving dramatically more. The same conclusion may also be drawn from Figure 9 or Table 1. The results drawn from three different studies of learning processes on an empirical basis thus all come to the same conclusion: it is far less worthy to invest in "excellence" (the right branch of the normal distribution), but instead to do everything to prevent a normal distribution, which implies early and intensive care for the laggards (the left branch of the distribution curve). This is the case in Finland (Table 1b) as well as in the genetic adaptative teaching (Figure 8b) or in the *erkenntnis*-oriented project study (Fig. 9), the successor of the genetic adaptative teaching, now also with a more intensive integration of knowledge from history of science, psychophysics and Gestalt theory.

Noteworthy is the opposite strategy, which was applied in the U.S. in the wake of *General Science Education* on the left branch of the distribution. There, nearly 50% of students fail (with

[26] The influence of parents' home on the PISA success in Germany and in most OECD countries is twice as big as in Finland.

[27] These deficits suggest that these students did not apply the "morning prayer", that is, the discourse on *erkenntnis*-theory every Friday morning, to themselves. These deficits point to barriers of learning resulting from chronobiology, a part of psychophysics. They are frequent, observable already at a young age, difficult to resolve and require further research.

[28] In the following semester at the university, an application was made to provide funds for tutors for specialist training in Technical Mechanics. This application was rejected by the students in the senate on the grounds that such a request must be extended to the whole university (with three locations and many faculties), of course to the same costs initially applied for. That would be fair. Such thinking, in which an acceptable target (equal treatment of all students) is made absolute without regard to resources lets one pause to reflect on the necessity of an *erkenntnis*-theoretical basic education for all students.

a level of up to 2, see Table 1a). It has not even been noticed or one did not want to notice that half the students have learned *nothing,* in spite of the high investment (which also extended to astronomy, chemistry and biology ([Sie12b]); one has sought the error exclusively in the teaching of natural sciences, looking in particular to physics rather than in the lack of Gestalt psychology and missing *erkenntnis*-theory. As noted before: both these areas are not apparent in the curriculum, but hidden in the metaphysics of the curriculum). Since one has not paid attention to those "left behind", to that particular part of the result or has taken the result as immutable normality, this deficiency was revealed only in 2008 with the publication of PISA 2006 ([OEC07]). One can do something against the not-picking-up of students in learning science and it is not even particularly expensive to do so. One must not condemn millions of people to not-learning.

7. LONG-TERM CONSEQUENCES OF GENETIC INSTRUCTION

So far, genetic teaching was examined primarily on a semester. How such teaching affects more than 10 years, has been at best examined in PISA.

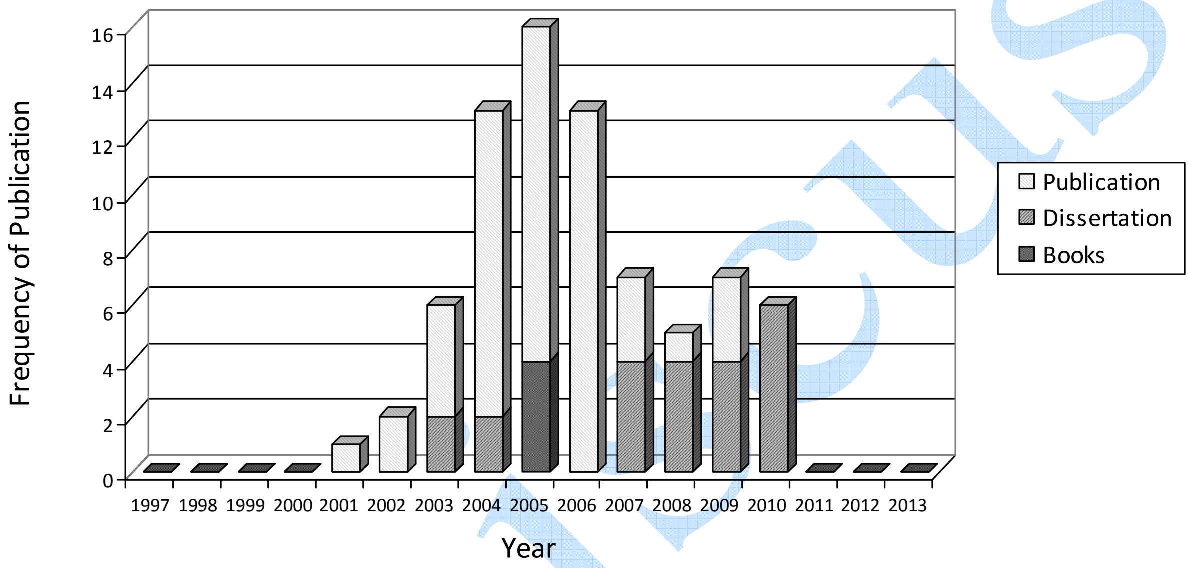


Figure 11: Frequency of publication after the start (and end) of the project study

Figure 11 shows the →number of publications from the Laboratory of Parallel Processes in the course of 10 years. Before and after this period there were, as the timeline shows, no technical publications. (The comparable cohort with the same examiners in other 10-year periods and for the students of electrical engineering therefore shows a zero-line! This is the key empirical difference, depending on whether at the beginning of the 10 years an *erkenntnis*-oriented project study was held or later. There have been no significant numbers of publications among students in computer science previously or ever since. The 68 publications of students at a university of applied sciences in a course program is unusual (probably unique) in Germany, 12 successful doctoral students as well.) Each light grey box documents a publication in peer review (5-15 pages, sometimes also 100 pages). Medium grey boxes of height 2 describe a dissertation (250 pages in addition to experimental work), the dark grey box with the weight 4 is a book of 600 pages. The project study for the first semester ran for 2 years, offered two times after 2001. After 2002, the department decided, as mentioned, to stop this "waste of resources" (a project day per week, Friday) in favor of lecturing theory with technical content. So the students were deprived of the methodological tools to themselves construct a world view and keeping it consistent. Without the shutdown of the project study in the first semester in Figure 11, so as of 2006 (the year in which the 2002 year of students could show the effect of the project study on their training) for all subsequent years, a series of columns in the same level as 2006 would probably have continued to the right (which would have been raised by two dissertations per year, as the years 2007-2010 indicate in Fig. 11). This number of publications is an impressive result for the *erkenntnis*-oriented project study, which is reached already after four years of its implementation.

The project study for higher semesters was still carried out by individual colleagues. The students could choose it. The proportion of *erkenntnis*-theory in the project study of the first semester (which the students with slight derision called morning and evening prayer) was closed by the action of the department. This crucial intervention stopped the reflection of the students regarding their own behavior. Only when clear deficits showed, the professors who held fast to the *erkenntnis*-oriented project study, worked partially to ameliorate them. The deficits are more rare (the students are not as confident to tell about them anymore), but more pronounced. In general, the deficits can be resolved within 6 weeks of collaboration between teachers and students, usually after a few days. The realization of a general self-control of students, however, was dramatically suppressed.

The initial publications were written by the tutors. The →publications then show a sharp increase up to 2006 (the year in which the students of the second turn have received their diploma, i.e. after 9 semesters, the standard period of study). Afterwards, some of the students wrote a →transfer report (a work in which they qualify for a doctorate in England). Then follow the →dissertations of the tutors, assistants and students from the project study in the following years until 2010. Together with the transfer report, this results in 3 1/2 years for a dissertation, the time it usually takes as a minimum in an engineering subject. The project study therefore - *viewed empirically* - *does not extend the period of study* (as opposed to the early assessment of students in Figure 6). The students are - as shown by their publications - not at a disadvantage in →"content consumption". These two concerns of the majority of the faculty in particular were, as Figure 11 shows, totally unfounded. The number of those who have qualified for a dissertation is 6% of students in the experimental group (see Table 1, FIN, and Figure 8). In the assessment of one of the authors → at least 15% of students could be considered by their learning achievements to qualify for a dissertation, if the funds for them to make a living had been available, i.e. had been generated in the region. These were missing as well as a minimum of support in the region after 2002.[29] In Leicester at the Software Technology Research Laboratory (STRL), all students worked on their dissertation alongside their part-time job (provided that job and dissertation did not have the same topic). Afterwards, 60 PhD students studied at the STRL, so a dramatic expansion at the STRL. This is a clear indication that this approach is a way in Germany for scientific universities[30] , that the number of doctorates there could be increased from 5% to 20%, if one could decide on using a similar way in the training and financing to the one shown here.

The quality of publications complies (through peer review) to international scientific standards. Some of the publications were published for young scientists by the society for computer science (GI), others at international conferences, others appeared in the Toolbox (with a circulation of 10 000), still others at the DeMontfort University in Leicester. Certainly, students who just enter with their publication into the scientific community cannot be measured on the same scale as experienced researchers. If one considers the book, the dissertations and a part of the other publications, one can certainly find a considerable amount of qualification. This qualification is definitely large in comparison with non-publishing for a long time.

From which date can one safely assess the effectiveness of the approach? The latest 4 years after the start of the project study in the first semester this seems to be possible. But already at the end of the 1st semester, there are clear indications, as the average of the exams passed increased from 54% to 81% and thus the problem of suspended exams for the subsequent semesters and of the late dropouts diminishes (Figures 9 and 10). If one would like to move this knowledge to an earlier point in time, questionnaires can be used, like those from which the Figures 1 to 5 have emerged and from which one can recognize being on the right track as early as 3 weeks in the first semester. In case significantly different results are obtained there, one should check one's teaching approach.

After 2010, the publications break down to zero in subsequent years. The *erkenntnis*-oriented project in the 1st semester did not take place for a while, the actual source of the subsequent publications dried up after 2002. One can obviously not remove the erkenntnis-theoretical, cultural, Gestalt psychological and physiophysical part without consequences for the number of publications, the core of the scientific debate, even if it is not so visible to which extent it contributes to optimizing the teaching. (The internal reports of projects of the

[29] in Anglo-Saxon regions is provided by industry or agriculture, a quota of jobs for college students to the regional disposal. This part of the doctoral students will be paid. The funds for 3-4 years cover modest living expenses and tuition fees. In return for this, the PhD students teach some of the regular courses.

[30] It is assumed here that the goal of universities of applied sciences relative to the universities is their applied nature. This can also be generated by scientific research (dissertations). The Gestalt psychologist Kurt Lewin once called this the "practical theory".
"But we must never fancy, as physicists have been taught to do by Faraday and J.R. Mayer in a more circumscribed province, that progress in the paths once entered upon, is the *sole* condition of enlightenment." ([Mac83/Mac88], p.2). It is thus helpful to deliberately change the perspective at least once in a while ([Sie12a, Sie12b]).

Laboratory of Parallel Processes as well as the diploma theses are not included in Figure 11.) From the dissertations in the area of influence of the Laboratory of Parallel Processes at the time of this publication already 3 professors have emerged, one with tenure in the U.S. Two of the new doctorates are still at least partially active in the region.

8. IMPORTANCE OF PUBLICATIONS

With the exception of the dissertations, no particular value was laid on publication, no one was pressured into writing them. The publications arose "naturally" from the attempt to carve out ideas.[31] They were not originally intended as a visible result of the *erkenntnis*-oriented project studies. Only their large number has led to including the publication, which is already a standard indicator of scientific work, into the evaluation of the project study. The colleague that worked on the project PSpice, had a similar increase in graduates over the comparable timeframe (Fig. 12).

9. DENIAL OF LIABILITY (DISCLAIMER)

The investigation of the *erkenntnis*-oriented project studies were carried out according to the criteria of carefulness. There are indications that part of what was done in the test is often not recognized in its → holistic meaning and therefore omitted in attempts of reproductions (for example, an omission of genesis or Gestalt psychology, using contents instead). Under such changed conditions, the results mentioned here - despite the name "Project Study" - may not be reproducible.

10. THE SEMINAR LaTeX

This two-hour seminar has been offered for 10 years at the university and is chosen each semester by about 15 - 20 students as an elective course. With it remained one non-content subject from the original canon. The students learn the language of TeX by Donald Knuth in the modification according to Leslie Lamport, LaTeX [32]. In this language, one may design books and mathematical papers in unprecedented visual quality, equip them, for example, with marginal notes or print equations in mathematical form. The embedding of drawings (for example, by vector-based tools such as Dia or by pixel-oriented tools) has been the subject of another project ([SS01b]).

In addition, in the first runs instructions were given on how to build a scientific paper, how one optimizes it by "kneading it through" and what one should pay attention on in the design. The scientific works of Figure 11 all have taken recourse to that experience. In addition, application letters were written in LaTeX, a quality of expression which cannot be achieved in other ways, with which one can generate a particularly individual cover letter. Overall, it was ensured that the linguistic expression became "a clever routine by different criteria" among the students. Only the elegant formulation for the sake of formulating was not practiced. There was a focus on bringing existing thought processes into a linguistically acceptable and presentable form and to print out this form. Thereby engineers are able to understand, express and optimize their own thoughts and tell them grammatically correct to others. This is a form of linguistic transfer.[33]

11. THE SEMINAR PSpice [34]

PSpice is a course of 2 SWS[35] with projects contained therein. It was acquired in 2002 by one of the authors and is an example of another part of the project study, which is popular with the students of computer science and electrical engineering. This example one can see that the students clever use of the opportunity to learn one content and at the same time other contents - in a sense *en passent* - ("Transfer"). One can see from this, that as a teacher one does not already need to be an expert in a *erkenntnis*-oriented project study in order to successfully participate in key parts of the project study and use it for the benefit of one's own teaching. Furthermore, one can see by the "transfer" the gestalts, which are hidden in PSpice (and can be made visible) and which are far-reaching for linear and

---

[31] Some artists talk of "releasing" a statue from its surrounding stone. Mach used the metaphor of "carving out" ideas in analogy to his observation of a girl (his daughter) trying to knit for the first time and moving all her muscles including her tongue along. Only with experience, the muscles actually needed keep being used in the process, while the others which are unimportant for the process are neglected bit by bit.

[32] see www.Dante.de

[33] Engineers often study engineering precisely because they find dealing with technical equipment easier than communicating with other people. Therefore, this communication (and the thoughts needed for it as a prerequisite) can be considered a hard and intuitively unpleasant task for many. It trains a different mode of behavior than they are used to (and good at from their own perspective). It thereby open up choices and combinations in different modes of behavior, which were not perceived to be available for the individual before. They become very successful with this in their jobs.

[34] for Spice see en.wikipedia.org / wiki / SPICE
PSpice see PSpice (student version), http://www.cadence.com

[35] SWS means Hours per week within one Semester

nonlinear systems. The PSpice software solves - invisible to the user - linear and nonlinear systems of equations and differential equations, and the Fourier transformation by the "push of a button". The two key words are "Kirchhoff's rules" (cuts in an electronic circuit as a whole) and "equivalent circuits" as applied to passive, active, non-linear, analog and digital components and cables, various types of transistors and diodes, controlled switches, cables, generally on a quadrupole (two terminal-pair network, dual port). The process of digital communications (e.g., QPSK) can be simulated with PSpice.

Apparently it is possible to evoke these gestalts in the learner without a degree in Gestalt theory. Afterwards, the students are able to build by themselves their understanding of a variety of electric linear and nonlinear systems, even those which the authors of PSpice could not have thought of (because the technology was not available at the time).

1. High-frequency technology. (4 SWS) Project-oriented implementation of the lecture and exam of the course was delayed for one year (the colleague was added in 2002) with the *erkenntnis*-oriented project-based learning (EPOL) from around 2002 with project work rather than exams. From summer semester 2003 onwards, a significant increase of this work is visible in Figure 12. This was followed, almost without exception, with very good project work.

2. Practical Microwave Electronics / EMC. (2 SWS + 2 SWS) The internship was, up to the summer 2004, an independent course in communications technology. It consisted of 7 experiments, which were carried out in the classical manner. After the contents reduction, 4 experiments were left. They are the absolute minimum content for a decent education of an RF-technology engineer! Project-oriented implementation was used since 2002. Laboratory tests are performed as projects with predefined topics. There is a rough guide with operating instructions for the complicated measuring instruments. In the lecture part of the internship, students learn to know the necessary fundamentals of the experiments. Under the guidance of professor and laboratory engineer they carry out the tests and create the test reports at home as a project in groups.

3. Satellite communications / radio astronomy. (2 SWS) PSpice was used for the representation of modulation methods and structure of receivers (PLL). Also in this elective area, the delayed increase by about 4 to 6 semesters was substantially similar to Figure 11. After summer semester 2009 this topic was no longer available (the professor retired).

4. Great Project (8 SWS)

5. Diploma theses in radio frequency technology. (8 SWS) The steep rise of graduate work in high-frequency technology after the *erkenntnis*-oriented project study - comparable with the increase in Figure 11 - also applies to PSpice and the high-frequency technology, see Figure 12 (for High Frequency Technology, PSpice was not originally designed).

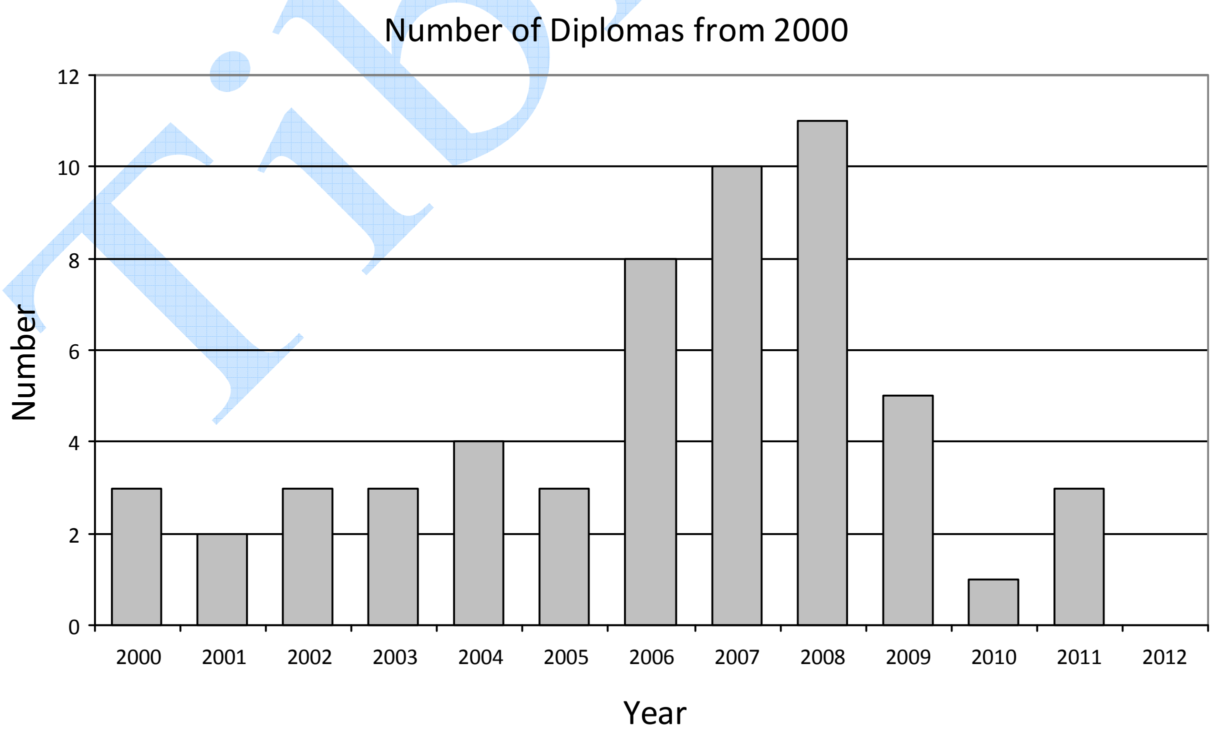


Figure 12: Number of graduate work in professional radio frequency technology prior to and after the end of the *erkenntnis*-oriented project study (at the time of the rise, see Figure 11).

Figure 12 clearly shows the influence of the "morning" and "evening prayer", i.e. the *erkenntnis*-oriented share of the project study on reaching the time of the thesis (with always about the same size of the cohort). One could call it an *erkenntnis*-oriented transfer, which is interrupted by the end the morning and evening prayer with exactly the time delay it takes to reach the thesis stage of the study. With the departure of the colleague in 2009 from active service, the seminar on PSpice continues, but the number of graduate work in radio frequency technology, however, diminishes.
The promotion of scientific research and dissertations in the proportion as shown in Figure 11 as an *erkenntnis*-oriented transfer, was not familiar to anyone of us at that time and was not expected in this form. A fly in the ointment remains, because the fellow colleague could not be briefed on the opportunity for dissertations, which offered itself to him. Therefore the colleague has unfortunately not been able to make use of his commitment and experience no doctorates in his field. The project and thesis work, however, are an essential characteristics of creativity and the thinking skills of the students.

The influence of PSpice on courses of other colleagues:
1. Telecommunications. (8 SWS + Practical 4 SWS) PSpice has proved an excellent preparation for the exam (written and oral). For example, in the winter semester 2010/11 students with explicit knowledge deficits were successfully prepared for the exam.
2. Practical Industrial Electronics (Pfl 5.Sem, 4 SWS) PSpice application is required for various practical experiments. Positive impact, because many students have already participated in the seminar PSpice. The test preparation is thus shorter and more effective.
3. CAD a required course in the 5th semester (4 SWS). Here is the PCB design with simulation of the electronic circuit part with PSpice is required. The prior knowledge of the circuit simulation of the seminar is a significant advantage for the students.
4. Practical GLE. (4 SWS)[36] In basic training ET 2 it is in some tests mandatory to simulate part of experimental set-ups (four-pole theory, resonant circuits, voltage divider circuits of energy) with PSpice.

[36] total of 50 SWS of lessons and practicals following PSpice

After the preceding considerations, one can distinguish three types of transfer: content transfer via Gestalt psychology as shown by PSpice and the Fourier transformation. The transfer of thinking processes into linguistically acceptable forms like with Latex, and the *erkenntnis*-oriented transfers that were done by the morning and evening prayers. In the latter there are additional elements that are referred to as key skills, and psycho-physical elements. While the first two forms of transfer were not objected to (perhaps with the exception of primitive genetic elements, which strongly felt strange for some colleagues (Appendix 1)), the *erkenntnis*-oriented transfer was anything but uncontroversial, not so much because of the "content" mediated there, but because of the intuitively assumed "waste of time", for which there is no empirical evidence.
The limited perception of unconscious or partially conscious learning processes leads some colleagues to the conclusion that the *erkenntnis*-oriented project study would provide too little "contents". This judgment is based on a linear model of learning. In this learning model no transfer can exist.
The Figures 11 and 12 show that it was not a waste of time, but that the self-reflection of the students, the gradual creation of a world view is a prerequisite for the success of the *erkenntnis*-oriented project study. If such an *erkenntnis*-oriented project study will be implemented a second time, especially the *erkenntnis*-based transfer should be examined in more detail.
As for the metaphysics of the curriculum, it would be a great gain if, instead of accumulating contents ("the cornucopia of contents"), the determining gestalts of the subject would be determined rather than specifying the content of the curriculum. Gestalts and phenomena which can be generalized for many subjects should be taught once and initially in general introductory courses. As can be seen on the example of PSpice, where the gestalts are re-used in twelve subjects with a much greater proportion of hours. It is obvious that it is appropriate to present them at the beginning in all intensity. Reuse in a different context is no problem thereafter.

Annex 1: An example of a genetic instruction in the form of sketches
Imagine a circular disk with radius 1. Was at its periphery at one point a hand crank attached. Show different projections at right angles to the axis of the circular disk in the plane of the circular disc, the hand crank in its circulation. The view from the front of the circular disc shows a rectangular triangle between the axle and a crank handle. The other two

sides of the triangle are the sine and cosine of the hypotenuse is the radius of one of the disc. The Pythagorean theorem can be read directly. The squares (areas) on the edges of the triangle are the formula $\sin^2(x) + \cos^2(x) = 1^2$ as a collection of formulas, but here visible enough to touch.

The circular disk with a hand crank will be extended to a cylinder set of radius 1, whose length is limited initially from -1 to 0 to +1. Around this "*one* cylinder" a coil (or thread) will be wound. In the simplest case this is a piece of thread without additional winding (zero winding) of the hand crank starting over the length of the cylinder ("Nullwindung") at its radius. The number of turns is in this case zero. "1" rotates the hand crank one revolution, is obtained on the length of the cylinder exactly one turn. In the same way can be integer multiples create an turn. The winding direction is determined by the direction of rotation of the crank handle.

In a separate chart a narrow rectangle of area 1 is shown at the zero point. This corresponds to the zero winding of the cylinder. Move this Rectangle to the abscissa on the one that puts a wrap on the cylinder. Moves the rectangle to -1 changes the winding direction. By changing the area of the rectangle to 2 is that the cylinder has radius 2 Thus, in this diagram by narrow rectangles, the situation on the cylinder set (several turns on each other). You can add small rectangles of different heights.

This mutual dependence of the diagrams can be reversed: it sets an integer multiple of spirals with different winding sense of the cylinder and receives the diagram of the narrow rectangles equivalent. This relationship is called transformation. The transform is e in machine, which maps over shifts of numeric integer values, the previous model. This is a prototype of the Fourier transform in time and frequency domain without specifying in mathematical formulas. Learners make that model in the form required by the discrete or integral form of the Fourier or Hilbert transform.

The model is initially detected and immediately tangible, perceptible. It initially contains internal inconsistencies (such as attaching the hand crank on the boundary of the disk). Unlike mathematical formulations of the archetypes are not precisely defined yet logically consistent, but workable. Gradually, it is transferred by means of thought processes of learners from tangible models in the formulas (Mach's thought experiments, [Mac97]). This approach can be described as illustrating with stepwise abstraction. It avoids what has also objected to Mach: premature abstraction ([Mac90], footnote 6), in the case of the Fourier transform in several places.

REFERENCES

[Bin11/Bin84] **A. Binet** - *Modern Ideas about Children* (1911; 1984). Albi: Suzanne Heisler 1975.

[Luc93] **A. S. Luchins** - *On Being Wertheimer's Student*, A contribution to the eighth international Scientific Convention of the Society for Gestalt Theory and its Applications (GTA) at the University of Cologne, Friday, March 26, 1993.

[Mac00] **E. Mach** - *The concept*. In: The Open Court Jun 1900, 14.

[Mac01] **E. Mach** - *On physiological as distinguished from geometrical Space* (1901). The Monist 11, 3; APS Online.

[Mac06] **E. Mach** - *Sur le rapport de la physique avec la psychologie*. L'Année Psychologique, Vol. 12: 303-318, 1906 - (see [Mac23/Mac87], No.32, pg. 589, in German)

[Mac09] **E. Mach** - *Erinnerungen an Darwin und die Entwicklungslehre*. Neue Freie Presse Nr. 16109. Wien 27.6, 1909.

[Mac10] **E. Mach** - *Sinnliche Elemente und naturwissenschaftliche Begriffe*. Archiv für ges. Physiologie, Martin Hager, Bonn. Bd. 136, S. 263-274, 1910.

[Mac13] **E. Mach**, in Jacob, J. Praktische Methodik des mathematischen Unterrichts. Pichler, Wien, 1913.

[Mac23/Mac87] **E. Mach** – *Populär-wissenschaftliche Vorlesungen*. Wien: Böhlau, 1923; 1987 - The quoted article is not included in the English edition of the Popular Science Lectures, which contains 15+2 articles, while the 5th German edition contained 33.

[Mac63/Mac78] **E. Mach** - *Vorträge über Psychophysik*. Hrsg. Thiele, J. / Österreichische Zeitschrift für praktische Heilkunde, Wien, Jg. 9, 1863; 1978.

[Mac75] **E. Mach** - *Grundlinien der Lehre von den Bewegungsempfindungen*. Engelmann, Leipzig, 1875.

[Mac83/Mac88] **E. Mach** – *Transformation and adaptation in scientific thought*. The Open Court: Jul 12 1888, 2/46, APS Online IIA. sowie Open Court, Oct. 11, 1888. 2/59, APS Online.

[Mac90] **E. Mach** - *Über das psychologische und logische Moment im Natur-wissenschaftlichen Unterricht*. In: Zeitschrift für den physikalischen und chemischen Unterricht 4/1, Oct 1890: 1-5.

[Mac92] **E. Mach** - *Facts and Mental Symbols* (1892). The Monist 2,2. APS online p. 198.

[Mac97] **E. Mach** - *Über Gedankenexperimente*. Zeitschr. f. physik. u. chem. Unterricht X, Heft 1, 1897.

[OEC07] **OECD** - *PISA 2006 — Science competencies for tomorrow's world*, Volume I and II, http://www.1600oecd.org, 2007. Cited 12 Jun 2008

[Sie01] **K. H. Siemsen** - *Abbrecherquote und erkenntnisorientiertes Projektstudium für Informatikstudierende*. Vortrag GI-Kongress "Informatiktage" Bad Schussenried, 9. November 2001.

[Sie11] **H. Siemsen** - *Ernst Mach and the Epistemological Ideas Specific for Finnish Science Education*. Science & Education, 20: 245-291, 2011.

[Sie12a] **H. Siemsen** - *Ernst Mach and George Sarton's successors: The Implicit Role Model of Teaching Science in USA and elsewhere*. Part I. Science & Education, 21/4: 447-484, 2012.

[Sie12b] **H. Siemsen** - *Ernst Mach and George Sarton's successors: The Implicit Role Model of Teaching Science in USA and elsewhere*. Part II. Science & Education, online 25/04/2012.

[Sie81] **K. H. Siemsen** - *Genetisch-adaptativ aufgebauter rechnergestützter Kleingruppenunterricht - Begründungen für einen genetischen Unterricht*. Peter D. Lang, Frankfurt, 1981

[SS01a] **K. H. Siemsen, Tanja Snaikus** - *A cognition-oriented project-study for students of computer science during the first semester* (Summer 2001, short version). Evaluation within Department of Electrical Engineering and Computer Science, Emden, 2001.

[SS01b] **K. H. Siemsen, Tanja Snaikus** (Gerhard Kreutz, Rolf Socher, Mitwirkung an 1.PDF) - *Projektorientiertes Studium im 1. Semester Informatik*, Interner Bericht im FB Elektrotechnik und Informatik, Emden, 2001.

[SS12] **K. H. Siemsen, Tanja Snaikus** - *An erkenntnis-theoretical project-study for students of computer science*, Annals. Computer Science Series, vol X fasc. 2, Timişoara, 2012.

[Thi64] **J. Thiele** - *Die Methodenlehre Ernst Machs und ihre Anwendung auf Probleme des exemplarischen Lehrens*. Schweizerische Hochschulzeitung SHZ Jg. 37, Heft 5, 1964, S. 294 - 304.

[Thi66] **J. Thiele** - *Hinweis auf Ernst Machs Lehrbücher der Physik anlässlich des 50. Todestages Machs* am 19, Februar 1966. MNU XIX, 1/2.

[Wol71] **H. Wolf** - *Lineare Systeme und Netzwerke* Springer, Berlin, Heidelberg, New York, 1971.

[Wol74] **H. Wolf** - *Einführung in die Nachrichtenübertragung* Springer, Berlin, Heidelberg, New York, 1974.