Acting Artist-like in the Classroom
– Modern Rational Technological World Comes to Life through the Creativity Arising from the Artistic Paradigm of Acting –

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Abstract: Mathematics education, in spite of all attempts to change it, has generally remained rigid instruction to use formulas in a technical way. Libraries are full of discourses that lay stress on understanding, intensity, active learning by discovery, relevance, pupil-orientation etc. In practice, however, little has changed. There is, at the best, a small group of students mastering a machinery. (Like a bulldozer. And afterwards they drive it and thereby reshape the landscape without realizing the entire outcome of what they do. – As expressed by Bengt Molander.)

The bulldozer metaphor highlights an essential error. In almost all our activities of everyday life we believe in following mechanical procedures. The core methodological error consists in transferring this pattern to pedagogy. We do not recognize that the logic of operational procedures follows different rules than the way of becoming acquainted with (and responsible for) these or even their development. When entering an area for the first time one needs to understand the complete range of possible methods and activities of this area and its environment. This is an act of construction, an act of creativity.

The paper claims revitalizing mathematics lessons by artist-like (mathematical!) activities. It incorporates aspects of developmental psychology as well as social demands, pedagogical principles as well as practical problems of everyday classes. Examples highlight the artistic paradigm giving creativity a real chance in mathematics education. Thus the personality of the pupil as well as demands of modern rapidly changing technically dominated societies are adequately respected.

Kurzreferat: *Künstlerisch Handeln im Mathematikunterricht – die zweckrationale Welt lebt aus der Kreativität des künstlerischen Handlungsparadigmas.* Allen Änderungsbemühungen zum Trotz, ist der Mathematikunterricht nach wie vor zu stark durch das Antrainieren eines technischen Umgangs mit Formeln gekennzeichnet. Bibliotheken voller Abhandlungen, die Wichtigkeit von Verständnis, Intensität, aktiv entdeckendem Lernen, Bedeutungshaltigkeit, Schülerorientierung usw. hervorheben, haben die Praxis zu wenig verändert. Im besten Fall lernen einige Schüler einen Apparat zu handhaben. (Wie einen Bulldozer. Und später bedienen sie ihn und walzen die Landschaft platt ohne zu merken, was sie da letztlich tun. – Wie Bengt Molander es formulierte.).

Die Bulldozer-Metapher weist auf einen wesentlichen Irrtum hin. Unser Leben wird zwar inzwischen fast ausschließlich durch das zweckrationale Handlungsparadigma bestimmt, doch ist es ein entscheidender methodischer Fehler, dieses Handlungsmuster auch in die Pädagogik zu übernehmen. Es fehlt ein Bewußtsein vom Unterschied zwischen der Logik eines Handlungsfeldes und der Weise des (verantwortungsbewußten) Zuganges zu diesem Handlungsfeld sowie der Logik seiner Entwicklung. Der Zugang öffnet sich nur durch das Verständnis von Methoden und Handlungsweisen dieses Feldes und seiner Umgebung, er ist ein konstruktives, ja kreatives Geschehen.

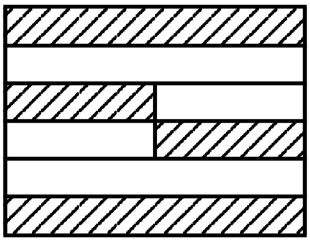
Der Beitrag fordert die Belebung des Mathematikunterrichtes durch künstlerisches (mathematisches!) Handeln. Er umgreift Aspekte der Entwicklungspsychologie wie auch soziale Forderungen, pädagogische Prinzipien wie praktische Probleme des täglichen Unterrichts. Beispiele verdeutlichen, daß mit dem künstlerischen Handlungsparadigma Kreativität eine Chance im Mathematikunterricht erhält, der dadurch sowohl der Person des Schülers als auch Forderungen der modernen, sich beschleunigt verändernden technisch dominierten Welt gerecht wird.

ZDM-Classification: C40, D40

We are not able to create nature, but we are able to destroy – and we do
We are not able to create creativity, ... – ...

Fractions in grade six. Exercise: Draw a rectangle with a 3cm base and a 4cm height. Shade 3/6th thereof.

Solution of a pupil:



The teacher mentions it to a colleague and comments: "While going through the classroom, that pupil asked me whether or not his solution was correct. I was forced to admit that it was. That's what you get when you don't tell the pupils exactly what to do." (mathejournal)

The pupil had done more than simply shade one half. He had also twice shaded 1.5 sixths. His pattern immediately makes a variety of other patterns come to mind. It was a creative solution! The teacher now reproaches himself for not having prevented this solution. He is obviously influenced by an insufficient understanding of what is mathematics, by the image of school as an institution for stuffing brains and by the exclusivity of the modern paradigm of technocratic action.

Even the best didactic suggestion will, as experience has shown, not change the attitude of such a teacher. Let me mention another example. Following in vogue suggestions for project-orientated and interdisciplinary teaching, a group of teachers had planned a block on Mozart in Music and German. The highest goal was to foster creativity. After the block had been taught, these teachers remarked in a published report that "Sometimes it was necessary for the pupils to work at a very brisk pace in order to stay within the predetermined timetable of the plan" (Schulintern). Mozart's creativity was, by the way, not fostered by systematic musical creativity exercises under pressure of time but rather by his daily three hour playing of the card game of tarot. (By the way: Fruitful development always grows out of polarities.)

Creativity neither develops within predetermined timetables nor, for that matter, according to any kind of exact planning. Therefore it is necessary to (finally) discuss creativity within a context with a wider horizon. And we should discuss it as a truly pedagogical issue. For creativity must first be *permitted*. It is *latent* in *every* child.

Even adults need a minimum of self expression in their daily routines at work, which has become widely accepted in business in the last few years. Since lean production is more cost effective, having each employee work with all aspects of production is replacing the taylorian specialised worker with no overview over the meaning of his work within the whole process (Kargl). With that in mind, the possibility of unfolding creativity within learning becomes even more significant.

Children as well as youth can only learn by their own production of knowledge. This is always a creative process and is the basis for developing individualised personality. Modern constitutions even guarantee the "free unfolding of personality" (e.g. German Grundgesetz, Art. 2). Yet it is standard practice that the same state which gives this constitutional right hires civil servants as teachers who try to structure their teaching in such a way as to quench the dispositions for creativity, as our opening example exemplified.

Such teaching is therefore unconstitutional. In truth a preposterous state of affairs. It harms not only the pupil, but also society itself, which desperately needs to generate *much* more creativity to solve its existential problems, indeed in all areas of life. Modern day commerce has no use for pupils graduating from school who have been trimmed to mechanically solve problems in exactly one pre-given way, i.e., like a machine.

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The greatest obstacle in supporting creativity is our fixation on the paradigm of narrowly goal-oriented rational action (zweckrationales Handlungsparadigma), which has become predominant. Everything is thought of in terms of production (and consumption). This leads into a rigidity that quickly converges towards death itself. Creativity, however, is rooted in a life-imbued process of growth. This is best thought of in terms of *artistic activity*. It has a goal but does not approach the goal in a straight line with a tank, but rather enters into multi-dimensional dialogues. Consider a sculptor. He has a sculpture in mind. But what he has in mind changes in the activity of sculpting. He reacts to the material (say, e.g., to a knot in the wood). He remains open to stimulus. He connects the activity of sculpting to his own biography. The work of art thus grows *in dialogue with the substance being worked upon*. Idea and reality work upon each other. Even though he works on details, these are always aspects of the whole because they are entwined with all other aspects: He continually sees the whole, both spatially as well as in time.

Precisely the loss of a sense for the whole is at the kernel of our modern problems. The fragmentation of the world into parts that can be manipulated is equally responsible for making the survival of mankind questionable as it is responsible for a technical (mechanistic) view of didactics, which culminates in the suppression of creativity through programmed instruction.

Just imagine how much creativity is suppressed through the fact that often no real dialogue occurs in the classroom. What pupils say is often rejected en bloc, instead of taking up a thought (that is attempting to be born) seriously. The latter would be a prerequisite for allowing the pupil to progress in *his or her* considerations (Köhler 1996 (a)). For the pupil, what is "true for me" is, in the end, much more decisive than what is "correct as such". This is similar to the artist.

> When a pupil thinks *one third* not as a cardinal number ♣♣♣♣ ♡♡♡♡ ♡♡♡♡ somewhere in a lesson but rather as an ordinal number ♣♡♡ ♣♡♡ ♣♡♡ ♣♡♡, this may be less comfortable, but that is no reason to stop the pupil from proceeding along *his or her path*.
> Similarly, when $x \to ax$ has been worked on in the class with creative zest and pupils come upon $x \to xx$, that is $x^2 \to x^2$, then one should not suppress the discussion simply because quadratic equations aren't due in the syllabus until next year. That would be suppression of creativity too.

When looking at the results of empirical educational research, it quickly becomes apparent that lack of an artistic approach is responsible for inadequate success in teaching. Characteristic for the artistic approach is *openness* (Köhler 1993) and *variability*. The artist also has methods and techniques, but does not use them mechanically. Rather every situation and every step forward are integrated anew within the wholeness of the surroundings. This is the reason why no two strokes of the paintbrush are exactly the same. The artist doesn't only ask about what *is,* but also about what *could be.* Wouldn't it be a central task of mathematical education to school a *sense for what could be* (Musil)?

> Let's consider an example: a German pupil claims that "1/4 von 32 ist 7" (1/4 of 32 makes 7). The reason: 1/4 is 25 and "von etwas" (of something), appearing in phrases like "4 von 20 abziehen" (subtract 4 from 20), means subtracting to him. He therefore calculates 32 – 25 (Altevogt). What had happened that 1/4 always means 25 to this pupil? How often may that have occurred in the classroom without variation? Or had he only been active in this moment as it occurred? (And analogue with "von".) Variation could have prevented it.

Padberg concludes from extensive studies of mistakes pupils make that lack of variation – for example in the number of decimal places – is responsible for many mistakes (Padberg 1996).

Lack of context is the next problem often faced. The paradigm of technocratic action holds sway over modern mass production. Everything not relevant to the process of identical repetition falls by the wayside. Exactly the same thing happens in teaching when the goal is to learn a predetermined and never changing method of calculation. Unlike in the serial production of cars, however, in the classroom this leads to a much greater number of failures. Too many pupils do not even learn the algorithmic methods themselves when taught mechanically.

An example for *working in context* (in contrast to the above):

> In a block on fractions with a strong emphasis on having pupils figure things out for themselves, the class comes up against the question of how to add two frac-

tions. The horizon of the discussion is not a narrow explanation (model) of how to add fractions, but the full context of fractions in arithmetic. Each pupil investigates for him- or herself how one might be able to add fractions. Just like a mathematician would work, numerous pupils try to apply the existing structure (of adding natural numbers) to the new set of fractions by adding numerators and denominators. Applying the structure of addition "directly" fails, of course, but the pupils notice this themselves. They thus make a substantial mathematical discovery! After extensive empirical studies, Padberg judges this "direct" method of "adding" fractions as the most likely mistake (Padberg 1989). Should they in future be uncertain, *these* pupils will probably be spared this mistake since they themselves had occasion to discover why this is an unsatisfactory method of adding fractions.

How were the pupils encouraged to work in this case? Like mathematicians! How do mathematicians work? Like artists, for example: like musicians. "By comparing two different disciplines", Metzler writes, "which are personally significant for me, I would like to develop criteria for creative activity. Being familiar with both areas, I am particularly sceptical with regard to the claim that typical differences can be ascertained when comparing the psychology of how a mathematician creates mathematics to how a musician creates music. Usually claims of this kind result from an insufficient knowledge of at least one of these disciplines. ... Each postulated difference of creative activity in mathematics and music should be examined closely to see whether it is a superficial appraisal, a prejudice or a simplification. Every difference that can be surmised sociologically should be scrutinised to see whether it points to a natural law or, more likely, to an impropriety. The latter is largely confirmed. I am thus inclined to make a playdoyer for a holistic approach to fostering the gifted: rational and emotional as well as intellectual and intuitive powers should be fostered together, for the sake of the person involved *as well as* for the results to be achieved." (Metzler, p. 46)

In suite let us listen to a remark of this organist and mathematician concerning competitions, which are often promoted as something that fosters creativity: "The *International Mathematical Olympics* are quite problematic, in that competition consists solely of a test setting. ... Many "olympic medallists" turned out to achieve only mediocre results in the German National Mathematics Competition [being not only such a test-setting–H.K.]. Passing a test is absolutely untypical of how the creative mathematician works. Mathematical projects mature over long periods of time." (Metzler, p. 61)

Learning is creative production of knowledge. And when we ask the cognitive psychologist, he will confirm that individual production of a system of knowledge does not consist of running through a chain of logical deductions (Weinert). We remark: *individual* production. This cannot be reeled out of the prepared frames of pre-planned teaching. We remark further: *production* is an activity that every one has to enact for themselves. We see that parting with the chain of logical deductions also means parting with a lesson setup that is planned and thought through completely in advance. The emphasis shifts to allowing pupils the right to make mistakes, take detours and enter into blind alleys – this can be observed with every painter when something is changed in the picture, thereby opening new perspectives.

Or let us look up what cognitive science has to say. Varela means the same paradigm shift when he demands that "the concept of the *evolutionary* process must replace the rational goal oriented construction". (Varela, p. 111)

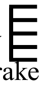
Stuffing pupils with "a chain of logical links" is in accord with the technical spirit of our age: We are setting up technical routines everywhere. We are making everything into technical and supposedly secure, calculable events. This decimates the world in its entirety as well as the process of real understanding in education and with it the possibility to rescue the world by means of a new youth. What is needed is to accept that the process of learning cannot be calculated in advance and that life's processes are open. A shelf can be filled up according to a predetermined scheme, but a pupil cannot be filled up systematically with knowledge.

For a "systematically taught" class, questions like the following are remarkably relieving: It is true that $6 + 6/5 = 6 \bullet 6/5$ and $8 + 8/7 = 8 \bullet 8/7$. Look for more such examples. Why is the sum equal to the product?

Learning is a process of creation and not of storage. (The storage metaphor, coming from the realm of computers, is not only stupid beyond expression but, in particular, incredibly dangerous.) It is thus necessary for the teacher to act contrary to the technocratic spirit of our age. The teacher must part with the convenience and security of technical procedures. *That*, and not working through a creativity enhancement programme stage by stage, is the prerequisite for fostering creativity. If we cannot convince the teacher to shift from a rational goal oriented paradigm to a paradigm of artistic action, then all other attempts to foster creativity are useless. We don't need more scientific studies about the possibilities of fostering creativity. Rather, by means of this shifted point of view, we must finally enable *putting into practice* what we have known for a long time.

The professionals in the field of didactics themselves work, by the way, quite artistically. They frequently introduce new concepts, for example, constantly changing their approach (so that a teacher trying to understand what they mean can hardly keep up). And they are obviously pleased with every new didactic model they create that can be tried on pupils. But all this is precisely not important. They should be pleased if they enable a *pupil* to be creative. The insight of the pupil–even when it is at odds with the conception of the teacher–should be the aim. It should be our primary striving that *the pupil* is pleased with his or her insight (Köhler 1996 (b)). It is therefore important to know what teachers strive after in consequence of their beliefs (Pehkonen and Törner pursue this, for example), for this is what needs to change.

The pupil's insight can only be facilitated by a challenging problem that is sufficiently demanding as well as being sufficiently accessible (gratifying). The pupil must be addressed in the region between boredom and frustration. Kindling creativity is, however, not the primary difficulty, but rather not to rebuke the creativity once it arises.

To exemplify this: A pupil was asked in the first year of school to copy . She drew . A mistake? No, a creative solution. "Because the rake works better that way", was her explanation when she happened to have been asked, instead of teaching her with the word "wrong" that creativity is not wanted. (Kowalczyk/Ottich)
A second example: In response to a question about the number of spaces between the stakes of a fence when the fence is circular (as opposed to a piece of a fence), the pupils had themselves finally formed a fence with their bodies in the classroom in order to pass judgement on the various opinions. This led to quite a commotion. Some pupils had evidently activated vivid mental images. Then a pupil asked right in the middle of all the mathematical considerations how it could be that in the garden of her grandmother a pear tree had bloomed in the middle of September. An irritating question because it took up valuable time of the mathematics lesson? The extensive activation of mental images regarding the garden fence seems to have helped this girl also mathematically. In the next lesson she had the best answer to a question deepening the combinatorial elements that are present when counting stakes and the intermittent holes.

Both examples are typical of how life plays directly into mathematics teaching. To permit creativity is to permit life. The artistic process of creation always incorporates the whole life of the creator.

Such relations to everyday life do not occur at the expense of mathematics. To the contrary: the attempt to restrict the mathematics lesson to what is mathematically exact and pure actually reduces mathematical substance. Examples such as the next two could be cited without end:

Since every step is practised and catalogued separately when solving equations, it was claimed within a group of teachers that the transformation from $2x + 3 + x = 5 + x - 1$ to $3x + 3 = 4 + x$ was not an equivalence transformation.
Or the following: a teacher writes in an appraisal of a textbook: "On page 19, the author allows only positive square roots, which is factually incorrect. ... He then discusses the problem of computing the coordinates of the intersection of a parabola in normal position with a horizontal line. Based on what was said previously on page 19, this problem is not solvable. ... Nowhere in the book does the author point to the ambiguousness of square roots."

In both of the cases above, the mistakes that these teachers make are not genuinely of a mathematical nature. They are mistaken in believing that everything must be defined in a pedantically precise way such that it is suited to solving exactly one kind of problem. They are indifferent to the mathematics as well as to the pupils, paying attention solely to applying their rigid system. Thus because one applies equivalence transformations because of certain problematical steps, only these steps are considered to be equivalence transformations; because two solutions of a geometrical intersection problem occur, square roots must occur in pairs.

Almost everything is determined by the way in which problems are presented by us. Who gives the artists problems to solve? The artist himself does, occasioned by some circumstance. In an impressive study, A. Hollenstein has shown that this is also the best method for teaching pupils. He gave one group of pupils an exercise to work on. A second group was only given the parameters of the given situation and asked to come up with questions that could be answered using calculation. The second group answered all those questions that had been given to the first group and then some more. Beyond that, the second group's calculations were more accurate and they came to more correct results than the first group (Hollenstein). This should not be surprising, for the second group was not under pressure to succeed within a fixed system but was their own sovereign in starting their own investigations within the given parameters. They could write freely on what they chose, with no fear of not being able to solve a list of predetermined problems within a predetermined time span.–What distinguishes the artist or the writer? An artist or a writer always says it afresh and anew. Similarly, pupils must be allowed to formulate anew and afresh what, for the teacher, has long come to rest in (his!) full clarity. Gallin and Ruf have been outstanding in their treatment of this (Gallin/Ruf). Stupid exercises show clearly what the goals need to be. How many solid bodies do teachers let pupils calculate where not one iota of insight beyond what is done by rote is called for? Why not problems like the following instead:

Pupils construct a cube from sheets of wood. They are to saw the six faces of the cube out of the wood sheets according to their own conceptions on how to make the construction work. In order for the pieces to fit together, the imagined construction must be drawn and calculated. Exact measuring and sawing is called for when cutting the wood. Three different kinds of construction are conceivable (listed below from the simplest to the most sturdy):

- Top and bottom faces k by k, in-between two side faces $(k - 2d)$ by k, in-between the two remaining side faces $(k - 2d)$ by $(k - 2d)$.
- Top and bottom face k by k, the four side faces $(k - 2d)$ by $(k - d)$ with the symmetry of a wind rose.
- All sides equally large $(k - d)$ by $(k - d)$, which necessitates filling in two (?) corners through cubelets with sides equal to d in length.

Figure included in print version only

Thus spatial imagination, measurement and calculation are already called for in order to make a construction. Before assembling the cube, the pupils could, by the way, calculate the areas of each side face to check the correctness of their construction (e.g.: number of cubelets in the third solution).

There are several possibilities in choosing the size of the cube. This depends on the situation in the classroom. To go into one possibility: There are many pupils who do not believe that one litre is a cubic decimetre. One could let the cube contain a cubic decimetre (for example through the second construction above, with a removable top) and pour the content of a litre bottle into the best constructed cube (which is, at the same time, a genuine recognition of good work, in contrast to the questionable competitions discussed above). Direct experience teaches better than talking about it! – The question of density may also surface in this discussion.

Even though the cube may not be constructed as an object for everyday use, it can very well be used as such once built (for example as a box for shoe cleaning utensils, for collecting scrap paper etc. etc.). Since overproduction is *the* environmental problem of our age, it is best to let children construct objects that can actually be used somewhere in life.

A variation would be rod constructions of solids made with wooden rods. They can be made into lamps by gluing on silk paper. Details of the construction (such as how three rods come together at a corner) must be thought out and imagined, drawn, measured, built ... A box for storing file cards can be covered in leather. Here, spanning surfaces will come up, calling for various measurements and calculations. A jewellery box would have to be partitioned on the inside and cushioned with felt. It readily becomes apparent that this approach will challenge all levels of talent and ability, allowing for natural differentiation to occur within the class. – "The most exciting is that reason and fantasy should forge an alliance through work." (Fucke, p.195 pp)

More generally: All problems with only one path to exactly one solution are suspect. Definitely unfavourable is the repetition of such problems with differing parameters.

Why are adults often unable to comprehend graphs, in spite of many years of sitting through mathematics lessons at school? Because they never went from given parameters to a graph on their own, for example from the race course

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to a velocity-time curve or a velocity-distance curve (and vice-versa from the graph to a racetrack).

Doubling the square: Go from □ to ? Really? Go from □ to ? Really? From □ to ! Yes, of course. Hence present the pupils with the last solution? No, on no account! Rather let pupils search for solutions. Here, playing around with sketches, looking at them, linking up with new ideas and thinking them through all intermingle. Here experiences can be made, world can be investigated.

In order for that to occur, the pupil must have sufficient first-hand experience. Davis and Hersh say: "You don't understand a cube if you always picture it from the same frontal perspective. It is helpful to look at it from many different perspectives. Even better is to pick up an actual cube, touch its corners and edges, look what happens when it's turned around. It helps to build a cube yourself, either bending and twisting it into shape out of a sturdy wire, moulding it out of clay or milling it out of steel." (Davis/Hersch, p.378)

The *capacity* to be able to have experiences through senses, feelings, and associations presupposes sufficiently developed senses. That would be a subject in itself (Köhler 1986). The school is increasingly called upon to help enable its pupils to engage in such rudimentary experience. Growing up in today's world demands an ever increasing capacity for integrating the widely diverging worlds of perception and of ideas, of the senses and of models. If the ability of the child to integrate is overloaded, this generally leads to depression, apathy and lack of orientation in space and time (Tarr).

To be allowed to work creatively, to learn to work artistically: that is the core of what a school must offer its pupils. (This brings significant improvements even in the training of apprentices (Brater).) They will then learn more positive knowledge on their own than what generally comes across through our teaching today. And, most importantly, they are taught to pick up whatever they may still have to learn at a later point in life with ease and when needed. Developing this capacity may be particularly urgent in this day and age, but it has always been called for by all the great pedagogical geniuses. With regard to this, I would like to cite a Spanish-speaking author here in Seville. In 1868 J. P. Varela said:

Para mí, el niño	For me, the child
no va a la escuela para aprender,	don't go to school to learn
sino a adqurir los medios	but to get the means
para poder aprender.	to be able to learn

We know that creative achievement presupposes an agility in recasting mental pictures, representations, models, images. Why then do didactic outlines normally try to assert a linear activity on a single and rigid track? Because it is captivated by the paradigm of goal-oriented rational action, instead of following the more appropriate artistic method.

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Epilogue by Detlef Hardorp

At stake is nothing less than how humanity will develop. Education has always paid lip-service to creativity, a word that is inscribed on the banner of almost every pedagogical idea. The time is long overdue, however, for a radical *implementation* of this often very vague ideal by applying the artistic method in learning. Without this, there will continue to be a lot of talk about creativity, which, in the classroom, will generally continue to be handled as a nuisance that upsets the course of well-planned education. The five year plans of Communist economies have become a relic of the past, because life cannot be squeezed into the straight-jacket of what bureaucrats develop on paper. Yet, in education, this kind of planning remains the norm. The teachers, the greatest potential that education has besides the children and youth themselves, are trained to pass on well-polished finished knowledge. This is analogous to attempting to teach pottery by looking at pottery that the teacher has made. It doesn't work. To learn pottery, you have to get your hands dirty and be willing to experience failure at the potter's wheel, through which *your own* skill can slowly be developed. It is similar in learning mathematics. All explanations, including the best of the best, remain incomprehensible before each student has found *his or her* clumsy entry into what it is all about. Mathematics is *creative* activity *in its essence and from its very beginning* and can never be understood passively. The failure to understand this sufficiently is responsible for a world-wide experience of failure when only all-too-finished mathematics is presented in schools.

The greatest mathematicians are the greatest dreamers. They dream of visions that will at best succumb to the arrows of their logic in the future. Before it makes any sense to shoot arrows of logic, inner pray must be developed before the mind's eye. The teaching of mathematics often limits itself to learning how to shoot arrows. This will remain a spurious exercise as long as it is not preceded by developing something to aim the arrows at through inner artistic activity. Inner artistic activity cannot be developed in thin air. It needs to be stimulated to awaken out of the richness of life itself, which is always multifaceted (as exemplified by the autumn blossoms of the pear tree in the example about the combinatorics of fences). When mathematics is dried out and withered up, no amount of colourful make-up will bring the corpse back to life. Even mathematicians have a hard time trying to understand the colourful modern mathematics textbooks in use in schools. What we need is a completely new culture of mathematics education.

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