Teaching to Understand

On the Concept of the Exemplary in Teaching

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If you can go to the source
don't go to the water jug - Leonardo

I

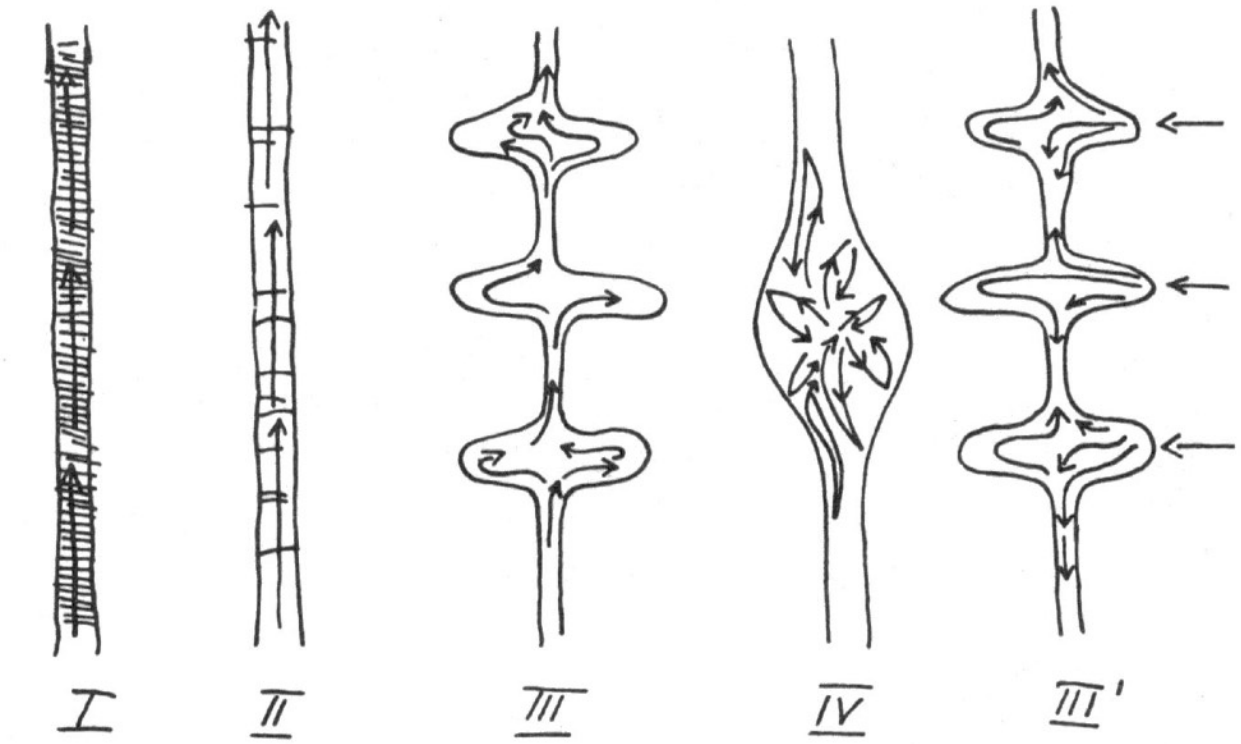
Let us begin by looking at what we have to steer away from if school is not to suffocate from the sheer mass of content and then perish as a kind of subject-matter processing plant. The older and more established a subject is, the stricter we tend to plan the learning steps. I'm thinking of mathematics - in contrast to a younger subject like social science - where we are likely to fall for the temptation to stick with prescribed steps, move from the simple to the complex, leaving out no step in a so-called systematic course of study. In mathematics we at first stay close to the axioms. In physics we begin with skills such as measuring, introduce basic concepts, and teach mechanics as the birthplace of physics. In biology we go through the world of the animals in linear fashion, starting with one-celled organisms and ending up with human beings (or the other way round), moving from the past to the present, step-by-step. In these approaches, the essential thing seems to be: Every single detail serves as a small stepping stone, leading the learner to something more complex and difficult, which he or she cannot yet grasp (see Figure I).

The reasons for working in this way are obvious. One thing builds on another, either logically or chronologically. There has to be order. If you leave something out, you will have to pay for it later. Every detail can be important, even if you don't recognize how at the moment. These reasons are "logical," but that is all they are. They are not pedagogical. They only see the totality of the subject matter and overlook the child. The child is seen as a small adult, quantitatively limited in its ability to grasp things. But to be a teacher means: to have a feeling for the process of human development, for what the human being is growing towards, for the awakening spirit. And to be a subject teacher means to know, in addition, both the subject's being and its becoming within the learner.

The basic principle, "first the simple, then the complex," has some validity. But this principle should not stand alone. Its shortcoming is obvious: very often simple things are either not really simple at all, or they are trivial. The law of inertia becomes more and more astonishing, the more one thinks about it. To fully comprehend it would need several lives as a researcher, and it is a lamentable thing to see it dished up on page 3 of an introductory textbook with an explanation that leaves out far too much. Einstein writes that the law of inertia is "usually the first thing we memorize in school physics, and one or the other person may even remember it" (1, p. 12). That certain angles are equal when a line cuts through parallel lines (congruent angles) may be believable, but the fact is too obvious. It is a boring observation that leads to nothing. It merely serves a purpose.

Such a systematic course of study doesn't give the learner long-lasting motivation. It only supports an anxious concern for what is to come, for the weighty edifice still to be built (which also burdens the teacher, even though he is familiar with it). The student thinks: what does the teacher have in mind for today? The teacher begins: today we are going to do the following!

An inherent temptation is completeness, which leads to haste and a lack of thoroughness. And an impressive heap of gravel is thus built up. Education is not a process of just adding. Just as adding thread upon thread leads nowhere, so also does the selective removal of threads (Figure II).



The fabric becomes threadbare and lacking in substance. The result will be a diluted systematic course of study. No one will think that knowing little is preferable to knowing much. But many a recommendation to give an "overview" and to offer the material in sweeping brush strokes seems to illustrate such a preference.

The Concept of the Exemplary in Teaching[1]

So what we need are selection criteria. We need to confine ourselves to the essential. Supposing we know the essential, a first worthwhile form for a course of study would be Figure III. We recommend the *courage to leave gaps*, which means the courage to be thorough and to dwell intensively on selected topics. So instead of evenly and superficially walking through the catalog of knowledge, step-by-step, we exert the right - or fulfill the duty - to really settle in somewhere, to dig in, to grow roots and take root. We don't want dissolution and isolation, we want continuity, but concentrations and intensifications within that continuity.

The particular aspect we delve into is not a stage in a process, but a mirror of the whole. Why? The relation the particular has to the whole, however, is not that of a part, step, or preamble; it is a center of gravity. It may be only one, but it carries the whole in it. This single aspect is not an element in a process of accumulation, rather, it carries and illuminates. It is not a stage in a progression, but it works like a spotlight. It affects things that are distant yet related through resonance. This is what the concept of the exemplary means (see Figure IV).

This is also what Ernst Mach (3; p. 344) means when he says that as a physicist he "would be satisfied, when every young man" (he forgets the girls) "has shared in the experience, so to speak, of a few selected discoveries of mathematics or physics and understood their consequences." Maybe Lichtenberg (4) points to the same thing when he says: "Something you have to discover for yourself leaves a trace in the mind that can also be used *in other cases*." Confucius, for one, is supposed to have said that he would send *that*

student away who wouldn't understand how to apply in the three other corners what he had learned in the first one. The clearest formulation is in the "Tübingen Resolution"[2] become *visible* through the *example* of a *single* thing the student has genuinely understood." I would like to add comments from two participants in the conversation at Tübingen: Hermann Heimpel says (6; p. 7) that "the universal is contained in the particular and can be found: Mundus in gutta (the world in a drop)," and that it is possible "within the framework of a general survey to come face-to-face with history in particular places, and ... to apply this to other areas." Wilhelm Weischedel (7) speaks of the "presence of the whole in the parts" and says that "something of the essence of history only really lights up in a particular event." (Italics in this paragraph's quotes are added.)

The concept of the exemplary is the opposite of specialization (8). It doesn't want to get stuck in particulars, it looks for the whole in the particular. "Impossible!" will be the response of the person who only knows addition.

Since we are primarily focusing here on refining a concept, we could say that radically exemplary mathematics teaching could limit itself, for example, to considering the one classical proof for the fact that there is no end to the series of prime numbers (9). In doing so it would make visible quite a bit (but not everything) that is characteristic for mathematics. The example is exaggerated on purpose and should not be taken as a proposal. Yet I'm convinced that a single such excursion, granted only that it is deep enough, could reveal more about mathematics than many a person has gotten out of mathematics who passed their finals unscathed. (For further examples in physics and mathematics, see references 11 and 12). Richard Goldschmidt (14) demonstrated 30 years ago how one can illuminate essential biology simply by looking at a roundworm. Kerschensteiner writes (13): "Forty years ago Prof. Götte of Strasburg wrote an excellent booklet in which all essential manifestations, concepts, and laws of the field of zoology were studied and put into context by looking at five to ten animals."

Spontaneity

So far I have purposely taken a somewhat one-sided approach by starting from the subject matter. But we also need to understand that the other half, the whole and spontaneous child, warrants just as careful consideration. We must consider both child and subject matter in equal measure, that is to say: the areas of intensification - the platforms - should also entail intensification of the activity of the child. They must be vivid and lead into the subject matter and into the soul of the learner. The process of mirroring must not only reflect the whole of the subject matter - ideally the whole of scientific pursuit - but should also bring light into the whole being of the learner (not only appealing, for example, to his or her intelligence).

Approaching and Getting in

Getting into a subject means plunging in - finding a relatively complex problem about which the students have no previous knowledge, a problem that will challenge them and elicit their spontaneous engagement. (Figure III)

Take optics for example. Instead of going through the customary sequence (luminous and illuminated bodies, shadows, rectilinear dispersion, darkness, etc.), we could start with a problem that Kepler (15) poses in his Optics (1604). He starts with the question where "sundollars" come from: "That a sunray, which penetrates through a slit, appears in the form of a circle on the surface beneath, is a fact everyone is familiar with. One sees this under dilapidated roofs, in churches with holes in the windows and likewise under every tree. Attracted by this wonderful phenomenon, people in antiquity have tried hard to find the causes for it. But up to now I have not found anyone who has found a right explanation" (15; p. 13).

Figure III tries to indicate that we enter from the outside and that energetic thinking leads to the basic concepts (to rectilinear dispersion in this case) and to more complicated questions. A second immersion repeats this procedure on a

somewhat "higher" level, for example, in the phenomenon that Goethe describes (20; pp. 58-62): A white pebble in clear water against a dark background seems not only elevated, but also appears to have colored edges, the more so the deeper it sinks. Starting from this experience we can explain all that is involved with refraction and dispersion, lead into the related topic of reflection, and move up from there to the spectrum.

So after plunging into a problem we dive down into what is fundamental and search for what is required to explain it. In this process we no longer amass and store data, but search for what we need, going to work in the same way original research occurs. An uncommon phenomenon demands our attention, and we in turn find the simple within it.

A tried and true entryway into mechanics is the seemingly harmless question, "Where does a stone land that is held out of a tower window and dropped?" Such a question seems trivial at first, but becomes confusing as soon as we think of the curvature and rotation of the earth. The complications are resolved by further thinking that lays bare the law of inertia, a proof for the earth's rotation, and above all: it opens up the way physicists think.

The challenge is choosing the problem one starts from. It should neither be too simple nor too complex, and we should not get too fanatical about the whole procedure. Keep in mind that the principle of going "from the simple to the complex" remains - in a limited way - valid alongside this approach.

The Exemplary as a Way of Experiencing

For the initial entry into the subject matter it may suffice that a problem is "interesting." But for an exemplary topic that should - all by itself - mirror the whole, we will need to aim for a stronger spontaneity, a deeper "engaged grasping" on the part of the learner. This would be the total opposite of the kind of "processing machine" that present-day schools are threatening to become. We need to reflect anew on the concept of "awareness" (66).

I quote Max Picard (16): "What characterizes the human being of our time is this: there is no longer an encounter between the human being and the object, it is no longer an event to have an object in front of us. We already have it before we have reached for it, and it leaves us before we let it go. We only get at the objects in a roundabout way, indirectly, provisionally, approximately, noncommittally, that is to say we do not get at the objects at all. Rather, they are delivered. It is as if everything has happened before.... All objects seem to belong to an enormous processing machine, which we human beings are part of: we are the place where all that has been processed is delivered. The meaning of an encounter, however, is to give an object we face time, and that means love." All this seems applicable to school situations, word for word.

It also has direct consequences for the schedule. Exemplary teaching doesn't fit in a chopped-up schedule with forty-five minute periods. It needs bloc scheduling so that we can work on the same theme for two hours every day. That way teaching and learning find a way into the hearts of both students and teachers - and will be working there day and night.

II

After this attempt to contrast the teaching according to the principle of exemplary with other teaching methods, I now turn directly to this approach with the following question. What is the nature of topics that can serve as examples - exemplars - for a specific subject, and what makes them so? What does "illuminating the whole," which I alluded to above, mean?

Posing this question immediately brings up what the answer should not be. Teaching should not result in a generally applicable "catalog of example materials." That would be the death of the actual procedure. From the point of view of the subject matter, it does of course matter what topic one chooses. But the teacher also needs to be personally captivated, which is always an individual matter. The risk and the uncertainty is an essential part of the process, something that K. Barthel has drawn specific attention to (23; p. 36).

Both teachers and students must be challenged by a problem, if it is going to be truly exemplary. And not only that, it should also challenge their assumptions. There is no need to have a narrow catalog of topics that can serve as examples, but a wide range of individual reports on what has been done in practice, not for imitation, but for stimulation. We teachers must listen to each other as individuals, not obey a preset course like functionaries. Also, we might not succeed at all in finding topics that are either strictly good examples (radiating), or only platforms (intensifying). But it is not superfluous to know what we actually value in a specific topic.

The Stirring Experience

In Heisenberg (26; p. 39) we find a biographical remark about his experiences in school that shows exactly what I mean. He says that "I found it extraordinarily remarkable and stimulating that mathematics somehow fits with our experience. Ordinarily the various landscapes of learning that pass by us in school do not make us feel at home in the world. The teachers illuminate them according to their capacities, sometimes brightly, sometimes less brightly, and we may retain some memories for longer or shorter periods of time. But in some rare cases something that has entered our field of view will all of a sudden become radiant … and finally the light it emits will begin to fill an ever greater space in our thinking, will begin to touch other subjects, and at last will become an important part of our own lives. That's how it was with me when I realized that mathematics fits with things of our experience ..."

In these sentences one clearly recognizes all the characteristics of the exemplary in teaching. That certain material, which he doesn't mention by name, became such a telling example was not because it happened to be intrinsically elementary (like, for example, force equals mass times acceleration). Rather, he saw that certain natural sequences can be conceived in terms of mathematics. Maybe we can call something like this fundamental (30; 59), to distinguish it from "elementary" or "basic."

We're not dealing with the "basics" of physics that allow the observer to solve many individual problems, but with something that lies at a deeper level, something that deeply stirs what is inseparable: the foundations of being human and the foundations of the subject matter. We see the human being in a new light and we feel how - under certain conditions - we are able to find mathematical natural laws. And we see nature in a new light. Nature gives itself over - under particular conditions and through the ceremony of experiment - to these laws. It remains, however, also beyond them, smiling enigmatically. Pythagoras and Kepler had this kind of stirring experience.

Such a stirring experience is not only interesting. And yet not everybody who can apply the axioms of Newton will notice that. You have to become at home in something before it will reveal itself in this way. This experience will then become radiant as opposed to being illuminated by a teacher who goes over it with you. It lights up, all of a sudden, provided patience preceded it. All these hallmarks are in complete accordance with what Plato said in his letters: "in the pursuit of knowledge, maintained over a long time, in dedication to the object of study ... [insight] appears all of a sudden in the soul as a light, kindled by a spark, which will continue to feed itself through itself"[3]. Insight fills a large space, not in the subject matter, but in our thinking, yes, in the space of our own lives.

We have here a rare, high-order occurrence in which a person is completely gripped, body and soul, by a fundamental experience. Such a formative experience stimulates true education. From this example we can draw the following general conclusion.

Certain topics, or more to the point, a certain problem, can stand as an example or exemplar of a fundamental experience. Galileo's question of how a ball rolls down an inclined board can be the exemplar for the fundamental experience that a sequence of events can be framed in terms of mathematics. Such a fundamental experience moves us and shakes up our relation to things and can therefore be called a truly formative experience. Insights into basic laws - such as the law of inertia in the case of Galileo's experiment -

are a necessary and unavoidable byproduct of this process.

It seems to me that such insights are essential in teaching physics, if it aspires to be a formative education, and to achieve this I see no other way than teaching according to the principle of the exemplary. Not because we wouldn't "have enough time" to "cover" the ever-accumulating knowledge, but because we have ample time. In any case, it would be pointless and futile to waste the time we have with accumulating information, for that neither schools us nor educates us. Exemplary teaching method is not a way out, chosen because of resignation. It takes us back to what alone can be seen as real teaching.

The infinity of space and the Copernican system (22) … are "dealt with" so superficially in schools that hardly a single senior in high school would be able to say why he believes the Copernican model. The pedantic assertion that what we see in front of our eyes all day long is "only semblance" is a result of shallow natural science teaching. It is one of those things that contributes to the destruction of a feeling of belonging in this world (31). This happens when natural science is presented superficially and hastily.

Since the discovery of modern natural scientific thinking, we human beings have ceased feeling at home in the world. But there has been gain as well: being able to calculate things mathematically awakens trust. Both things need to be valued rightly in physics education, which must have as a goal recognizing and demonstrating how physics sheds light on only one aspect of nature. I wouldn't know how we could approach this goal other than through thorough, exemplary consideration of appropriate problems.

The Exemplary in Biology

The developing and differentiating stream of living beings is unique, like human history, and cannot be grasped in categories of causality but rather in morphological categories. The multitude of present-day forms only represents a cross-section of this stream. The conceptual system of modern physics and chemistry is inadequate to comprehend it (at least that is the way it seems to the layperson, especially when he is a physicist). "If we apply the methodology of chemistry, the answer can only be expected to come from the realm of chemical processes" (37).

Accordingly, Portmann's (38) assertion that there are two fronts in biological research is convincing to the layperson. The first goes into ultramicroscopic detail in penetrating genetics and physiology, researching structure and function of living substance. The second, promoted by Portmann himself, is a new morphology that keeps to what the naked eye can see, understanding shape, form, and gestures as "signs of the way the inner being manifests itself."

What does the teaching method based on the principle of the exemplary have to do with fundamentals in teaching biology? I wonder if it means the following. First, that by doing an exemplary physiological experiment, every one of us can learn that chemical questions will generate only chemical answers and, second, that an adequate way of grasping life would require another conceptual system, probably morphology. This would apply both to forms as they appear to us today, and to their natural history.

The second front is emerging again in our time, having been dormant since the time of Goethe. For teachers it is important to realize that this second front, the morphological approach, is pedagogically the first. Because that is where the child is at home. It is where the child can have the most intensive, inward experiences of the kind we have characterized as exemplars. Such experiences are not seldom destroyed in school by treating plants or animals too early from a purely physical perspective, as if that would do them justice. I remember being disconcerted when I saw a teacher putting a white flower in ink, which proceeded to rise in the plant. In doing so he violated the plant (as I would put it now). A biology teacher will usually take no notice of this, because he has gotten used to suppressing such objections as irrelevant. In other words he acts as if physicalist categories would be adequate for life. No child will believe this. Children can only express their disbelief through aversion, and I'm inclined to go along with them.

So we should wait longer than is currently done with physical and chemical questions and foster the morphological approach, because, as Portmann says (38), "Cytoplasmic research, which penetrates into the realm of the invisible, necessarily leaves the familiar world of the senses - the everyday world we experience - behind. It goes into a different realm and does not encompass the sphere of human experience in which the richness of nature's creations fosters our life of feeling and nourishes our creative imagination. When we do research down into the sub-microscopic level, penetrating into the molecular structure, we leave the realm in which we are at home."

The goal, which the biology teacher can attain while still remaining in the sphere where we are at home, seems to me to be that "every living form goes beyond what it needs for survival" (38), which is to say that a columbine, a peacock's tail, or bird song should never be understood merely as means to an end, but as something that Portmann calls the self-presentation of organisms ("Selbstdarstellung des Lebewesens"). This is what Stifter means when he says "The artist produces his work in the same way that a flower blooms, and even one in the desert, where no gaze falls upon it."

Isn't this the pure soil where teachers should start? Shouldn't we linger here long and give the children time to experience the selected exemplary examples? The wrong way to start is to fall into the routine of "all right, it is winter, time to start teaching human biology, let's take the skeleton out of the biology closet." It is still being done this way around fifth grade, but you couldn't find a deader way to begin teaching about life. And from there on to all the skeletons, to the bellows that simulate the lungs, and to all the rest of the system. As an example of an alternative way I quote Portmann, where he aims at something truly pedagogical. In his essay about leaf forms (42; p. 24) he says, "Whenever we devote ourselves lovingly to nature, even just to a simple collection of leaves, we awaken healing forces of the soul." The words "healing forces of the soul" show how a truly pedagogical chord is sounded here, in a way that is almost forgotten in our schools today. Modern education rarely keeps in mind that the objects we observe can have a healing effect. The main aim is thinking analytically about the subject matter and practicing that skill. But education will only be truly formative when there is no rift that cuts us off from the deeper wellsprings of our souls.

A misunderstanding could arise here, namely, that I would wish to ban the exact analytical research of living substance from the world altogether or at least from schools. On the contrary, I believe this approach can open up something essential, simply by virtue of the fact that it teaches us to see more exactly and penetrate our observations with thinking. The microscope - which Kierkegaard (43) so rightly mocked, saying, "If Christ had had a microscope, he would have used it to check out the apostles" (1846) - cannot reveal the essence about things. It is true that when we have only dim notions about certain processes in space and time, a microscope can bring certainty.

But there is something decidedly more important that analytical research can show us. When we slap our leg, we are basically all convinced we are touching the same old body we have always lived in. But we now know from chemical isotope research, as Butenandt reports (37), that all structures of living organisms, including bones and teeth, are constantly being built up and destroyed. So we cannot think of our body in mechanistic terms, because it is in flux equilibrium.

So the body of an organism is not what the physicist calls a body, but it is a process. We would recognize our mistake sooner if the process were to run more quickly. If we want to compare a human body to something physical, we shouldn't think of a stone or statue but - and even this would not yet be exhaustive - of a whirlwind that sucks up and again drops dust as it moves along, or a cumulus cloud, a fountain, a flame, or a river.

A true grasp of this reality changes radically how we appear to ourselves and others appear to us. We look differently at youth and old age, at healthy and sick people. And the corpse appears as a trace someone has left in the sand. We recognize that our bodily state in space and time is not static, but rather see it as "only" the idea of

a formative process that continually incorporates matter and then discards it again. That such a view "creates demands for the transformation of biology teaching at all levels is something that is hardly recognized today, and it will definitely create hefty demands in the near future" (Portmann, 38; Walther Klumpp has given valuable suggestions for high school, 44).

We can divide the fundamental experiences of a subject, which can only be won by the teaching method relying on the principle of the exemplary, into two categories: those that strengthen our feeling of being at home in the world and those that weaken it. The natural sciences are able to do both. Rational understanding of certain natural processes awakens trust, while this trust is shaken again by the demystification accompanying the analytical process. To avoid the feeling of loss becoming dominant, we need to, first, observe carefully and, second, always remain awake to scientific methodology. When we do that, it turns out that the feelings of loss, barrenness, and fright are only erroneously called forth because we take one aspect for "reality" and add up the various (often contradicting) results, instead of recognizing them as different perspectives on one and the same thing. We are then protected against seeing living phenomena only as physical or chemical processes and viewing history only as a biological process.

An Encounter

For biology, and perhaps for physics, there may be yet another entryway that could almost be called magical. It arises through an experience that opens us to all other aspects of a discipline. This entryway has nothing to do with the particular methods of the discipline, neither is it an outcome. It is a onetime event, bound to the particular grace of a lesson, a name, a mood, a teacher. It can hardly be planned, and comes close to an "encounter" in the true sense of the word. It often has to do with opening the way to the right insight, with clearing away misunderstandings and prejudices, partly those that school has put there.

I know the case of a girl who had previously been unable to find a connection to biology, but suddenly found it the moment a teacher took her by the hand, went into the garden, and just showed her the flower called "Love in a Mist" (Nigella). The name and the shape told her in one moment not only what this flower is, but provided a key to all others.

The colorful flash of a single, first drop of dew in the grass can spark insight into the nature of physics, namely that everything having to do with apparatuses is of a secondary nature, derivative, and a means to something else. This insight, when arrived at in the right mood, can dissolve mountains of dark misunderstandings into nothing.

Aiming for the Sources

So what is the essence of the exemplary in teaching? Is it perhaps the breakthrough of the principle of self-directed learning into deeper, almost existential layers? Is it the attention toward the fundamentals of a particular discipline, what it attends to and also ignores? Is it the sober assessment of how the revelations of physics, biology, or history can make us lose our feeling of being at home in the world, only to re-establish this feeling by making transparent what we actually do in a particular discipline and what it does to us? And, is it looking directly at what needs to be discarded?

All this would entail quite a different aim (even though sometimes the same topics would be involved) from the usual benumbed confinement to a particular discipline. We always have to fight this tendency in ourselves, and also fight the compulsion to amass material.

Who knows whether in 50 or 100 years we will even shake our heads or smile any more. If we do, we will definitely shake our heads about a school system that believed any good would come out of amassing half-understood information presented as gospel truth. At the beginning of this essay I spoke about "courage to leave gaps," which is easy to misunderstand. What I meant to say was: courage to be thorough, to be original.

In place of the idol of broad and static completeness, which makes us work too frantically to fill a storehouse of knowledge, we clearly look for something new. We boldly aim for the sources. The aim is not to cover every last detail, but to reach the inexhaustible sources.

This is a translation and condensed version of Martin Wagenschein's German language essay "Zum Begriff des exemplarischen Lehrens" (published in his book Verstehen lehren*, Weinheim: Beltz Verlag, 1997, 11th edition, pp. 27-59; the essay was originally written in 1956). Translation by Jan Kees Saltet and Craig Holdrege. Copyright 2008 The Nature Institute. A different translation of sections of the essay has been published under the same title in the book* Teaching as a Reflective Practice: The German Didaktik Tradition *(edited by Ian Westbury et al. Mahwah, New Jersey: Lawrence Erlbaum Associates, 2000, pp. 161-76). We borrowed the title for the essay from that translation and are grateful to the translator (Gillian Horton-Krüger) for finding such a felicitous expression for Wagenschein's difficult-to-translate phrase "exemplarisches Lehren."*

The complete essay can be viewed at http://natureinstitute.org/txt/mw/exemplary_full.htm.

References

[Translator's note: we have left the references, which are German language publications, in German and in Wagenschein's original format. Only where he made editorial comments have we translated into English. The number of each reference is the same as in the original full-length text.]

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(2) Wilhelm Flitner: Der Kampf gegen die Stoffülle: Exemplarisches Lernen, Verdichtung und Auswahl, Die Sammlung, 1955, S. 556 ff.

(3) Ernst Mach: Über den relativen Bildungswert der philologischen und der mathematisch-naturwissenschaftlichen Unterrichtsfächer der Höheren Schulen; (Vortrag 1881); in: Populärwissenschaftliche Vorlesungen, Leipzig, 1923, 5. 313 - 355.

(4) Lichtenberg, Aphorismen.

(5) Abgedruckt in den Zeitschriften: „Bildung und Erziehung", V. (1952), S. 58 ff.; „Die Höhere Schule", IV (1951), 5. 6 ff.; „Die Pädagogische Provinz", 1951, 5. 623 ff.

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(7) Wilhelm Weischedel: Sinn und Widersinn der Wissenschaft. Deutsche Universitäts-Zeitung X. Heft 18, S. 6 ff.

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(10) Karl Menninger: Mathematik in Deiner Welt, Göttingen, 1954, S. 51.

(11) Martin Wagenschein: Das Exemplarische Lehren als ein Weg zur Erneuerung des Unterrichts an den Gymnasien (mit besonderer Beachtung der Physik). Hamburg (Verlag der Gesellschaft der Freunde Hamburg 13, Curiohaus) 1953, 3. Aufl. 1964. See also Martin Wagenschein: Ursprüngliches Verstehen und exaktes Denken, Klett Stuttgart, 1965; 2. Aufl. u. Bd. II, 1970. [Contains all of Wagenschein's journal articles cited in this article.]

(12) Martin Wagenschein: Das Exemplarische in seiner Bedeutung für die Überwindung der Stoff-Fülle, “Bildung und Erziehung” 1955, 5. 519.

(13) Georg Kerschensteiner: Wesen und Wert des naturwissenschaftlichen Unterrichts, 3. Auflage, S. 116.

(14) Richard Goldschmidt: Einführung in die Wissenschaft vom Leben der Ascaris; Berlin, 1927 (Bd. 3 der Sammlung „Verständliche Wissenschaft").

(15) Johannes Kepler: Ad Vitellionen paralipomena (1604) - Zusätze zur Optik des Vitelo. - Auszug in Ostwalds Klassikern der

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(16) Max Picard: jenes Bild, das sich auf das Urbild bezieht; in: Wegweiser in der Zeitwende, Hrsg. v. E. Kern, Ernst Reinhardt Verlag. München, Basel, 1956, S. 79. See also his book: Die Welt des Schweigens, 2. Aufl., Erlenbach-Zürich, 1950, S. 74.

(20) Martin Wagenschein: Natur physikalisch gesehen; Frankfurt, 1953, 4. Aufl. 1967, 5. 58 ff.

(21) Martin Wagenschein: Konstruktive Stoffbeschränkung im physikalischen Unterricht; Der Mathematische und Naturwissenschaftliche Unterricht, VII, S. 165 - 172.

(22) Martin Wagenschein: Die Erde unter den Sternen, München 1955; 3. Aufl. Weinheim, 1965.

(23) Konrad Barthel: Über exemplarisches Lernen im Geschichtsunterricht; „Die Sammlung", 1956, 5. 35 - 47.

(26) Werner Heisenberg: Das Naturbild der heutigen Physik, Rowohlts Deutsche Enzyklopädie, Bd. 8.

(30) I'm indebted to Eduard Spranger for this felicitous choice of words. Cf. Eduard Spranger: Die Fruchtbarkeit des Elementaren; in: Pädagogische Perspektiven, Heidelberg, 1952, 5. 87 ff.

(31) Martin Wagenschein: Das Exemplarische in seiner Bedeutung für die Überwindung der Stoffülle. Bildung und Erziehung VIII (1955), 5. 519 ff..

(37) Adolf Butenandt: Was bedeutet Leben unter dem Gesichtspunkt der biologischen Chemie?, Universitas X (1955), S. 475 - 482 Auch in Kröners Taschenbuchausgabe Bd. 230, S. 97 - 108.

(38) Adolf Portmann: Aufbau eines neuen Erlebnis der Natur; Biologie auf zwei Fronten. Stuttgarter Zeitung 31. 12. 1955, S. 35.

(42) Adolf Portmann: Ein Naturforscher erzählt, Basel, 1955, S. 16 - 24 (43) Kierkegaard, Tagebücher, ausgew. v. Theodor Haecker, 4. Aufl. München, 1949, S. 246/7.

(43) Sören Kierkegaard: Tagebücher, ausgewählt von Theodor Hacker. 4. Aufl.. München, 1949, p. 246/7.

(44) Walther Klumpp: Das Grundphänomen in der Biologie; Der mathematische und naturwissenschaftliche Unterricht, VI (1953/1954), S. 104 - 109.

(66) Martin Wagenschein: Über die Aufmerksamkeit, in: Zeitschr. f. Päd., 1959, Heft 1. See also: Martin Wagenschein: „... zäh am staunen" - Pädagogische Texte zum Bestehen der Wissensgesellschaft hrsg. von Horst Rumpf. Seelze Velber, 2002, S. 26-37.

(67) Horst Rumpf: Das Exemplarische als Weg zu geschichtlicher Wirklichkeit, in: Geschichte in Wissenschaft und Unterricht, 1959, 5. 479.

Notes

[1] Translators' note: Wagenschein uses the term "exemplarisches Lehren." He means a holistic principle of teaching that leads to deep understanding. He later used the term "genetic-socratic-exemplary teaching and learning," thereby emphasizing that the focus of this concept is not the subject matter but rather the process of learning (qualified as "genetic") and teaching (qualified as "socratic").

[2] The "Tübingen Resolution" was a recommendation brought forward by distinguished scientists - Carl-Friedrich von Weizsacker, Walter Gerlach, Eduard Spranger and others - to reform high school curricula in Germany by reducing the abundance of content-matter and deepening scientific understanding.

[3] Plato's "Seventh Letter," translation from German translation of Plato's Letters by O. Apelt, Leipzig, 1918, p. 72.