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PERSPECTIVES FOR BIOLOGICAL EDUCATION-CHALLENGE FOR BIOLOGY INSTRUCTION AT THE END OF THE 20th CENTURY

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ABSTRACT:

Some surveys of over 200 beginning semester students preparing for a teacher's certificate in biology at the Technical University of Berlin indicate that biology instruction is not considered a very popular subject. Biology instruction in Germany is too abstract and theoretical, too cumbersome and inaccessible to the normal student. Biology instruction is approaching its lowest standard in history in most federal states since the majority of these states have taken biology instruction out of grades 7, 8 and 9. The methods of biology instruction, the objectives and the content are among the central issues related to biology instruction in Germany. A paradigmatic model expansion and/or change by necessity is needed to enhance the current curricula of biology instruction.

KEY WORDS:

Biology Education / Instruction, Biology Instruction in Germany, Didactics of Biology, School Biology,

ÖZET:

Berlin Teknik Üniversitesi'nde biyoloji öğretmenliği bölümü birinci sınıf öğrencileri arasında yapılan bir araştırmaya göre, biyoloji öğretiminin çok popüler bir konu olmadığı ortaya çıkmıştır. Gerçekten de Almanya'da sürdürülen biyoloji öğretimi hem çok soyut ve kuramsal hem de normal bir öğrenci için oldukça sıkıcı gözükmektedir. Eyaletlerin çoğunluğu da biyoloji öğretimini 7, 8 ve 9. sınıftan kaldırdıkları için Almanya'da biyoloji öğretimi bir çok eyalette tarihsel olarak en düşük standartlara yaklaşmaktadır. Almanya'da biyoloji öğretiminde karşılaşılan önemli sorunlar arasında biyoloji öğretim yöntemleri, bu öğretimin hedefleri ve biyoloji öğretim müfredatının içeriği yer almaktadır. Biyoloji öğretiminin geliştirilmesi için paradigmatik bir model genişletilmesine ve/veya değişimine zorunlu olarak ihtiyaç duyulmaktadır.

ANAHTAR SÖZCÜKLER:

Biyoloji Eğitimi./ Öğretimi, Almanya'da Biyoloji Öğretimi, Biyoloji Öğretim Metodları, Okul Biyolojisi.

1. DIFFICULTIES OF BIOLOGICAL INSTRUCTION IN GERMANY

The brook
by Heinrich Schulmann

The teacher
analyzes the book.

He exhibits a picture.

He draws on the blackboard.

He describes.

He explains.

He narrates.

He writes down notes.

He gives dictation.

He assigns homework.

He administers a test.

Behind the schoolhouse

is the brook

flowing its steady pace,

away and away.

Now, it's all over.

Some surveys of over 200 beginning semester students preparing for a teacher's certificate in biology at the Technical University of Berlin indicate that biology instruction is not considered a very popular subject. These students were asked in the process of free association to write down whatever memories they had of their own past biology instruction in school. The answers were overwhelmingly negative (77.5%, cf. diagram 1).

diagram 1: Recollections of past biological instruction

teacher's methods 40.0%

teacher's personality 25.5%

use of media 12.5%

teacher's knowledge 3.6%

selection of contents 7.2%

miscellaneous 11.2%

negative evaluations - recollections of biology instruction

Given these observations, my claim states the following: Biological instruction in Germany is too abstract and theoretical, too cumbersome and inaccesible to the normal student. Thus, I believe it is time to work on an inventory, now that the

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establishing and consolidating phases of the didactics departments and especially the didactics of biology have come to fruition. This inventory can only be outlined superficially here due to shortage of space. Such an inventory cannot, however, proceed in an isolated manner. Those recognized deficits need to be identified and elaborated. At the same time, the achieved standards and what has been accepted by most ought to be articulated. Both, in turn, should be implemented for the development and elaboration of heuristic and pedagogical demands for a future-oriented education in school biology that perhaps may one day be in a position to place demands on official educational policy.

2. SCOPE, METHODS, OBJECTIVES AND EDUCATIONAL SUBJECT MATTER OF CURRENT BIOLOGY INSTRUCTION

If the scope, methods, objectives and contents of biology instruction are analyzed, which is what I have been doing for the past 20 years, one can become aware of a series of faulty developments.

Let us begin with the scope. Here, the complaint can be made that biology instruction is approaching its lowest standard in history in the majority of the 16 federal states of Germany, given the limited time alloted to it during the entire period of mandatory school years. In addition, what adversely affects the continuity and reputation of this discipline is the fact that in most of the federal states, biology instruction has been taken out of grades 7, 8 and 9 completely. These students have reached an age which is most suitable for the appropriation of scientific thinking, given their personality development and intellectual maturity prevalent within this age category. The second point of the analysis refers to the currently dominating methods in biology instruction. Although the exhaustive feed-back obtainable from practical experience can only be interpreted as tendencies, one thing, however, is clear to me: As a result of the constantly increasing burden of the faculty (e.g., with administrative work, disciplinary problems, parental inquiries and unmanageable class-size of up to 30 students or more), the above-mentioned cognitively overloaded subject matter and the often missing equipment and instruction material, a teacher-centered, as a rule frontally conducted, abstract biology instruction lacking in the implementation of media resources dominate the German schools of today. The third point is the objectives of our discipline: despite the multiplicity of school curricula in the different federal states, one common denominator remains: cognitive learning goals dominate too heavily. In other words, the necyclopedic transmission of knowledge has not yet been replaced by any viable alternative. However, biological education is more than investigation and acquisition of faetual knowledge. It also includes the following features:

- the ability to be open and perceptive toward biological phenomena and problems;
- the capability of orienting oneself within a social context;
- the acquisition of judgmental capabilities and learning facilites;
- the realization of a "biologically - oriented lifestyle."

These supplementary features conform to what Theodor Litt, the great German pedagogue of the first half of this century, stated as well as the famous contemporary Mittelstrass of the German Federal Board of Education.

The fourth point of the analysis refers to the biological educational content itself. Here, an extraordinarily wide range of topics is revealed, which is not surprising. These topics cover practically the complete spectrum of the traditional subdisciplines of biology within a totality of more than 200 different biological items. If one were to analyze with the objective of discovering structures, fundamental objectives, source and meta-principles for the execution, evaluation of importance and selection of biological learning content, the following would become obvious: the random concatenation of biological learning material is presently the decisive factor in the biological curricula of Germany today.

Neither a coherent basic concept nor a minimal consensus regarding a comprehensive execution or source can be identified in either the old or the new federal states. The leadership and organizational debate in West Germany has been interrupted for over 10 years and has yet to be renewed. If in German curricula any sources ever become revealed at all, then they end up being generally depicted as systematic and structural in nature (e.g., adhering to biological subdisciplines, to systematic representations of plant and animal species). Seldom are human-oriented perspectives and methodologies relevant.

Even today, a concept for a uniform biological basic instruction is still missing which can be divided according to chronological order into grades 1-13 or 1-12. Curricula in Germany is still being extracted out of the various biological subdisciplines and unmethodically "pasted together" to form a random "collage." Thus, very little consistency or coherence can be found in the curricula. The tendency of biology instruction to overwhelm the student with a mosaic of constantly changing facts and petty details is still great. Such a situation produces an excess in cognitive material that overtaxes the students' receptive capacities.

The scope that modern biology covers has become quite broad, ranging from moleculat structures on the one hand, i.e., molecular biology, to global constellations on the other hand, e.g., ecology of the biosphere. The specialization of the many curriculum designers and biology teachers carving out this broad continuum in a multiplicity of ways leads to an enormous fragmentation and, in most cases, to a loss of the ability to competently gain a comprehensive view of the whole.

Here is where the pedagogical responsibility of the curriculum designer should intervene. We must face the challenge of our discipline becoming disintegrated by looking for a unifying didactical context.

In order to accomplish this task, we need the cooperation of the specialists in the biological field, since biology has become classified into a multiplicity of subdisciplines, as we previously mentioned. Therefore, only a team composed of the various biological disciplines is in a position to establish significant associations and common ground. Didactics of biology is dependent on the cooperation between field specialists on the one hand and pedagogical scientists on the other. After all, it is impossible to incorporate the entire complexity of the field from the sole perspective of biology didactics.

diagram 2: Didactics of biology between biological theory and pedagogy

independent inquiries and research

didactics of biology

biology as a discipline of the natural sciences

general didactics

In summary, the analysis of theory and practice of school biology and didactics of biology yields the following observations:

1. A unifying principle for biology instruction for grades 1-13 still does not exist to this day.
2. The empirical deficit in didactics of biology is still great.
3. Throughout the entire curricula, schoolbooks and instructional conventions in biology, a neglect of affective and pragmatic objectives is apparent.
4. Throughout the entire federal states, time is being cut short for biology instruction during the mandatory school years. Further reductions are likely to occur.

3. THE NECESSITY FOR PARADIGMATIC MODEL EXPANSION AND/OR CHANGE

Given the previous analysis, a relatively constant orientation towards the features of living substances can be detected as a minimal common denominator despite the existing heterogeneity and lack of coherence in current curricular design. This perservering factor allows for an important concern of comtemporized biology instruction to be met, namely that the students should be able to gain insight into fundamental phenomena of living systems which are manifested in specific and concrete examples and events.

This fundamental principle, however, is not sufficient enough for us - as we shall soon see - to successfully plot a demand - oriented course. I believe that new impulses and intellectual contributions are imperative in order for us to face the most important challenges of biology instruction in the year 2000, which are:

- the enormous explosion of knowledge in more than 100 subdisciplines of biology;
- the many problems of the modern living world include essential biological elements;
- many issues that spill over to other disciplines ranging from health education to ecology are predominantly addressed in biology instruction;
- the environment has changed dramatically in the last 15 years;
- school, biology curricula, instructional material and methods have, nonetheless, remained the same;
- the ever present ecological world crisis.

Consequently, we find ourselves in the midst of a legitimacy crisis regarding the selection, sequence and evaluation of biological learning material. For example, we should ask ourselves: what concept of man should we convey? For a long time, even within the tradition of Christian moral standards, the exploitation of resources to the detriment of plant and animal species which also depreciates already existing developed landscapes was considered legitimate (conforming to what is written in the Bible: "Make the Earth your servant"). Likewise, an egocentrism has prevailed which has been justified especially by the quest for technical progress. This egocentrism culminates in the fulfillment of physcial pleasure. In fact, the sensation of pleasure is enhanced with the increase of performance!

On the other hand, people are concerned with humanizing their lifestyles and reconnecting with

nature. We need to place nature in a position equal to man. Without a plausible context that transcends the various disciplines, we will not be able to find a solution to this legitimacy crisis.

The philosopher Nietzsche once defined "science" as the removal of a state of confusion through the postulation of hypotheses. In this sense, I would like to convey some thoughts that could serve as a guideline for actualizing a means of selecting, evaluating and assembling biological school content. I believe that didactics should be prepared to promote either a paradigmatic model expansion or at least a model change and investigate what fundamental ideas and metaprinciples are necessary fo a biology instruction of the future.

A paradigma (greek: para-deigma = structure, model, example, original image) is the totality of thoughts, perceptions and values that display a particular view of reality.

Science should not limit itself merely to describing the phenomenal world, but should also take up the assignment of envisioning what might be possible for the future. We should always be prepared to reconsider our notions and options and assess the viability of alternatives.

It seems to me that a change in paradigmatic model for the biological sciences is now in a developmental stage. There are enough indications for this in the literature among a series of intellectual forerunners (e.g., Hass, Giordan, Schaefer, Vollmer). An inventory of currently available items in the biological sciences shows that we are about to enter an era of the new biology - a third biology, leaving behind the empirical, analytic approach with its emphasis on causality. (The first biology was - as is generally known - the descriptive and classifying school, e.g., that of Linné and Darwin.) The new biology makes use of the systems theory and the ecological method. It is holistic. In other words, it encompasses the totality, is allconnecting and a proponent of inclusive thinking.

Given the above context, biology didactics could pose the following preliminary questions:

1. Under what criteria should learning material be selected?
2. How should this material be presented? In what succession? With which associations?
3. How should learning material be evaluated?
4. How can its burdensome aspects be lightened?

Exactly such considerations belong, in my opinion, to the main tasks of (biology) didactics. This discipline represents an "institutional quest in motion, "as the Hamburger pedagogical scientist Gunther Otto once formulated it succinctly. Essentially, biology didactics should serve as an aid to making decisions and providing structure for curricula, schoolbook and last, but not least - instructional work and activity. Furthermore, biology didactics should deliver an intellectual agenda for biology instruction, especially in light of the overwhelming volume of particularities in biological data.

What we must first do is to transcend the fundamental principle of the features of living substances and look into the field of human life as a subsequent guiding principle. In other words, it should become obvious to the student that humanity is, in the end, the starting point and final goal of all inquiry that takes place in school biology. An additional determinant for the selection of biological material should be the consideration of the multiplicity of organisms. Especially up until the 8th grade, the procedure should be to always provide characteristic illustrations of particular organisms as an instructor is delivering knowledge of a certain species to the students. For instance, whenever an ecological topic is being addressed, an exemplary approach serves as an ideal learning method.

Consequently, not only does new material mould the new school, but also new horizons and perspectives, which ought to be discussed prior to presenting the newly selected material. We as educators do not have it easy, here. As the 20th century is coming to an end, the realization has increasingly taken hold that learning material selected and sequentially ordered strictly according to the systematics of biology or according to morphological or anatomical criteria is no longer adequate. These criteria cannot meet the requirements of the lifestyle of our achievement-oriented industrial economies. As the European Conference of Education Ministries has already pointed out correctly in 1978, we should be providing biology instruction for future non-biologists in the regular schools, which also includes senior school.

If, on the other hand, we examine the almost overwhemling number of daily life situations and difficulties involving biology and the natural sciences and view them in relation the disposable time made available for them in the classroom (for example, when biology is being taught), then we can realize that we need to resort to overriding fundamental guidelines in order to meaningfully select, evaluate and sequentially order biological instructional mate-rial of the future. Otherwise, we will continue creating biology curricula as a random and incoherent concatenation of existential events having something to do with life and life processes.

Learning today for the challenges of tomorrow characterizes a specific didactic approach which has already been outlined by the social scientist and contemporary humanist Schleiermacher of the first half of the previous century, as follows:

"Every pedagogical moment involving a reference to the future must simultaneously fulfill the needs of humans in the circumstances of the here and now."

The new paradigms we are searching for must therefore conform to a greater degree with the needs of the present than has heretofore been the case. The German researcher Bernd Löwe - as is commonly known - has emphasized this point repeatedly in various investigations regarding interest research (the most current being in 1992).

4. THE DEVELOPMENT OF FUNDAMENTAL GUIDELINES AND PARAMETERS FOR CONTENT SELECTION

The contents as well as methodological reform of biology instruction aims at achieving the goal of selecting, evaluating and sequentially ordering that appropriate instructional material which will serve to prepare students for the foreseeable challenges of the year 2000. This activity is being performed with the aid of new and unconventional thinking patterns, general principles and comprehensive contexts.

As one explores for such general guidelines that correspond to the current intellectual development in the biological sciences, it may be helpful to look directly to nature itself as a source of orientation. In nature, we can discover a series of organizational principles that can be didactically "exploited" to a far greater extent than has been the case up until now. Such a metaprinciple which transcends even the boundaries of the field of biology is the principle of polarity, suitable for being demonstrated to a classroom audience as a fundamental universal model for gaining insight into the workings of nature - even to students during the mandatory school years.

diagram 3: The tree as a paradigm for binary correspondence (as a demonstration of complementary polarity)

negative geotrope

positive geotrope

This principle, so self-evident, so profound, yet so simple, constitutes an essential part of the wisdom of ancient philosophers (e.g., in Aristotle or in Lao-Tse). Indeed, it penetrates every life phenomena and is inherent in life itself. Life is always oscillating between polar opposites, e.g., between stabilization and destabilization (let us take health as an example which - according to Lao-Tse - is an unsteady state of limbo moving back and forth between two volatile conditions). In this sense, polarity is a characteristic feature of life which in biology is so universal that it is surprising that it has never occurred to anyone yet to use it as a metaprinciple in biology instruction. Only in Hamburg's biology curriculum for senior school has this subject been incorporated into the instructional material.

It is noteworthy that, whenever the features of living substances are being represented in curricula, schoolbooks as well as in the actual biology instruction itself, for the most part only the one side of the polar opposite receives mention. In almost all cases, it is active movement that becomes the focus of attention, and seldom active rest, i.e., mechanisms of activity breakdown, catabolism and regeneration such as night rest, hibernation or other forms of wintering (e.g., defoliation). This "non-productive" element seems to be the object of suppression.

In reality, polarity is not a goal in itself, but rather a means to an even greater goal. In general, life processes attempt to overcome polarity by incorporating themselves to form life-sustaining organisms within a more expanded whole (cf. Schaefer 1990). For instance, cells dying out is a very important process for life which ought to be the topic of discussion next to the usual instructional discussion of growth processes. Until a while ago, people used to think that solely the formation of new cells was decisive for the vital sustenance of a multicellular organism. Actually, special enzymes are generated for the self-destruction of cells in the organism (so-called apoptosis) which induce an orderly cell death in order to make other life possible. For example, a certain type of leukaemia results when too few white blood cells are being destroyed, allowing a pathological excess of them to remain. Furthermore, plant growth hormones (auxines) are produced from dying cells.

Accordingly, every organism is constantly concerned with establishing a balance between both polar opposites inherent to life itself, between mutually antagonistic processes and entities.

If we allow students to find out how living substances bring about an interrelationship between two contrasting phenomena and events, we will notice that living substances can resort to two ways to establish this connection:

- either they satisfy each polar opposite separately and successively. First, they deal with one pole, then with the other, in sequential order. In other words, they swing from one polar opposite to the other in a certain chronological pattern (e.g., being awake/sleep/being awake or some other biorhythm or periodic cycle);

- or they satisfy both polar opposites simultaneously, fulfilling their contrasting demands, however, in distinctly seperate places.

The equilibrium targeted by the system is attained in most cases between the two competing processes and/or entities, but not in all, regardless of whether it takes place within a chronological or within a spatial context. The principle of polarity as a general fundamental principle for biology curricula affects biology didactics tremendously. It

- promotes dialectical thinking (thesis/ antithesis/synthesis);
- enables the creation of a pool of knowledge and thus the acquisition of insight into the regularities of life processes;
- allows for a comparison with contradictory or diverging positions;
- allows for a consideration of vital situations from different perspectives.

This leads us to a development we are striving for regarding problem - solving strategies. Such a development directs us to ecological thinking (i.e., the AHMAZ principle), whose approach is inclusive, cohesive and holistic. The principle of polarity needs to be explained in a variety of ways in the classroom. Another illustrative device is the transfer of this biological rule to other fields of application not confined to biology itself. For example, the polarity of exclusion with border opening and border closing as polar opposites can be illustrated by refering to the different economic communities (EFTA, EEC, GATT), to windows and doors within a building and to national boundaries between two sovereign states. Furthermore, the different schools of thought characterizing inclusive and exclusive thinking (e.g., segregationist apperception among right-wing extremists; mind-expanding conceptualizing among ecologists) can be employed as illustrative examples.

Here, it becomes evident what exploitative capacity is available in this biological rule and what heuristic potential it contains for gaining greater insight into the secrets of life itself.

Given the fact that, in our intellectual tradition, we tend to focus on only one conceptual approach (in accordance with exclusivist thinking) and see only one side of the coin, not paying any attention to the other, it is essential that this metaprinciple be constantly utilized, exercized and universalized in the course of biology instruction. In the lower grades (primary school), it should be first presented inductively, manifesting itself from the particular to the universal (implicit stage). It is then in the upper grades where the explicit elaboration of the principle (concrete, explicit stage) should take place. Finally, an application of this principle to non-biological examples can follow in senior school (e.g., phenomena involving social structures, economic systems, the nature of the psyche and other functional models). In addition, the principle serves as a suitable context for interdisciplinary subject-matter regarding ecological and health education.

We must first experiment with the guiding principle presented here and test it in the classroom at different pedagogical levels. Preliminary results have been quite encouraging. Other determinants - e.g., those that have already been proven effective - and other parameters regulating selection and organization of material (e.g., the spiral principle or other universal principles of vital events) should then follow suit. In this way, the challenges of the future can be met that will be confronting biology instruction in the next few years. I believe that the positon I have attempted to outline here in this paper regarding conceptual learning is feasible for future policy. Not only the bare instructional subject matter, but also the conceptual tenets themselves (e.g., the principle of polarity) will become the means through which biological insights and phenomenal accounts are grasped. Here, it will become apparent that a coherently conceived biology instruction for non-biologists oriented toward the learning process as well as toward the needs of the future is in the best position to accomplish the goal of representing biology not only as a science of life, but rather as a science for life, thus superseding the limits of convention.

5. CONCLUDING REMARKS

I believe cautious optimism is called for at this stage of development regarding the methods of biology instruction. The progressive incorporation of the perceptual, experiential and witnessing aspects of biology into the learning process, especially when they are accompanied by instruction outside of the classroom, is reassuring, since now the opportunity to transmit and consider moral values (e.g., responsibilty toward humanity and the world, limited resources, maximizing chances for survival) based on the fundamental principles of life has finally arisen. This method also encourages me to be optimistic, because it does not suppress the technical and empirical knowledge of biology. On the contrary, it provides this body of knowledge with a solid foundation for its cognition and apprehension. Once the content is "digested" by the intellect, the processed information and insight can be made available for reflections concerned with human responsibility.

The following poem provides a contrast to the preceding poem in the introduction addressing the same topic. It should convey the idea that, despite all the heretofore enumerated difficulties and problems, even today a problem and school-oriented biology instruction is possible. The instructors need only to employ their own creativity!

The brook
by Lothar Staeck

The students
select the brook
as a classroom project

They perform à site inspection.
They engage in research.
They investigate.
They analyze.
They observe with the microscope.
They make determinations
and make assessments.

They exhibit their results.

Behind the schoolhouse
is the brook
flowing its steady pace.

By experiencing, participating and understanding,
the project won't be over
for a long time to come.

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