New directions in Biology teacher education[1]

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SUMMARY

In this article, I will first discuss the implications I see for Biology Teaching, emerging from adopting an "Integrative Biology " approach: giving another meaning to Biological concepts, changing the aim of learning and developing new skills, starting from questions, problems and/or projects rather than from the logic of Biology, developing an interdisciplinary process.

In a second part, I will illustrate the connections between this way of seeing Biology and its teaching, and the current needs of the secondary schools.

Finally I will try to illustrate how we can translate " principles " of Integrative Biology Education into teacher education activities by describing one activity for future Science teachers at the Catholic University of Louvain. The results of this type of activity will be reported.

KEY-WORDS : integrative biology, Biology teacher education, science in context, Biology teaching.

RESUME

Cet article aborde tout d'abord des implications de l'adoption d'une optique "intégrative" de la Biologie pour l'enseignement de la biologie.

Il tente de relier cette vision de l'enseignement de la Biologie aux besoins actuels de l'enseignement secondaire.

Dans une troisième partie, il montre comment une vision "intégrative" de l'enseignement de la Biologie peut être traduite en activités de formation d'enseignants. Dans cette perspective, une des activités réalisées à Louvain-la-Neuve en formation d'enseignants de la Biologie est présentée et analysée.

MOTS-CLEFS : "biologie intégrative", formation des enseignants de la biologie, science en contexte.

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I am involved in Biology Teacher Education at the Catholic University of Louvain. We prepare teachers for working with upper secondary schools students (i.e. students ages 14 – 18). In my talk I will address four points.

- First I will remind the " integrative Biology " approach adopted by IUBS.
- Second, I will discuss the implications I see for Biology Teaching, emerging from this way of seeing Biology.
- Third, I will illustrate the connections between this way of seeing Biology and the current needs of the secondary schools.
- Finally I will try to show how in Louvain-la-Neuve, we train future teachers to be aware of and to implement this approach to Biology Teaching.

1. New trends in the way we see Biology

Younès points out the evolution that has occured in the way we see Biology in Biology education: " During the period extending into the 1950's, emphasis was on consolidating biological disciplines …>From the sixties onward, IUBS scientific activities were pursued with three basic principles in mind : international, global and interdisciplinary collaboration, with a strong focus on linking biological research and education to societal needs. More recently, the IUBS program " towards An Integrative Biology " was adopted . The main challenge facing the Union will be how better to promote integrative biology research and education, the better to address the many complex biology related issues and problems we encounter in our lives, individuals and societies and in our environment." [3]

For Wake, "Integrative biology is both an approach to and an attitude about the practice of science. It seeks both diversity and incorporation. It deals with integration across all levels of biological organization, … and diversity across taxa. It provides both a philosophy and a mechanism for facilitating science at the interface of… disciplines, in both research and training. Work at interfaces involves discussion of significant problems amongst scientists with diverse expertise and perspectives."[4]

2. Implications for teaching Biology using an " integrative " point of view

What does the adoption of an Integrative Biology approach mean for Biology teaching?

2.1. Giving another meaning to Biological concepts taught.

If we accept an integrative conception of Biology, we should not teach Biology concepts only because they are part of the scientific knowledge of the discipline . We have to justify their place according to some criteria. Giordan (1985) and later Millar (2000)[5]

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[3] Talal Younès *Biology International. The news Magazine of the International Union of Biological Sciences (IUBS)* n°38 January, 2000. p. 1-2

[4] Marvalee H. Wake. " Symposium on Alternative Reproductive Strategies " Biology *International. The news Magazine of the International Union of Biological Sciences (IUBS)* n°38 January, 2000. p. 3

[5] André Giordan " Culture scientifique et technologique, régulation de la démocratie et vie quotidienne " In Gérard Fourez *Enseigner les sciences en l'an 2000*. Namur. Presses universitaires de Namur 1989 p.5-13

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proposed justification for teaching Biology concepts beyond the need to provide scientific knowledge for itself.

The first justification for teaching Biology concepts is the fact that concepts are important and useful in everyday life (utility argument).

The second justification is the fact that an understanding of the Biology concepts is necessary if one is to participate in discussion, debate and decision-making[6] about issues which have a Biological component (democratic argument).

The third argument is a cultural one. Scientific knowledge is a major achievement of our culture and therefore all students should be exposed to these achievements.

2.2. Changing the aim of learning and developing new skills

The arguments made suggest that schools need to rethink their educational goals for Biology education. Specifically they need to prepare people to use Biology knowledge rather to memorise facts.

2.3. Starting from questions, problems and/or projects rather than from the logic of Biology

Instead of starting from the scientific content in itself and for itself, an " integrative Biology " point of view should start from a question (For example: describe by a schema your eye and its functioning and ask questions about what you would like to know about it), a problem, a role play,… In this kind of teaching, the content emerges from questions rather than from the logic of the discipline.

We should no longer teach the structure and function of the eye first and then discuss problems of vision. This sequence of instruction places emphasis on the facts rather than on the knowledge. An alternative instruction sequence would begin with students curiosity and prior knowledge about vision and visual disorders. Question about short-sightedness would lead to introduce information of the eyes structure rather the other way around.

Some teachers think that with this view of Biology and its teaching/learning, we will never " cover " all the " biological concepts " that have to be taught. The question is : what does " cover " mean ? To cover does not mean "understand" but rather memorization. Griffiths and Mayer-Smith [7](in press) pointed out the justification in terms of rigor given by university and college science professors for covering such huge amounts of Biological knowledge. In their book, Griffiths and Mayer-Smith propose the principle "less is more" "Rather we seek and expect coherence and precision in argument, and a capacity for flexible performance.

2.4. Developing an interdisciplinary process

Adopting issue of adapting an " integrative " model of Biology education suggests we must assume an interdisciplinary approach in our Biology classrooms. Returning to the topic of " vision ", it means that teachers should assist students in understanding principles from Biology (structure and function of the eye), Physics (light diffusion).

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[6] See also P. Fullick and Mary Ratcliffe *Teaching ethical aspects of science*. Great-Britain. Bassett Press 2000

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3. To what extent is an "integrative view of Biology linked with the needs of the current secondary school?

Many educators, including secondary school teachers, re-searchers in education, educational philosophers and school sociologists say that " we live in an age of uncertainty, and that uncertainty can be confidently expected to increase. We can say very little about the year 2020. Its technology, its jobs, its patterns of employment, unemployment and self-employment, the nature of leisure, lifestyle and family life, its environmental and ecological concerns "[8]

Furthermore as Giust-Desprairies (2000) says " since some decades, cultural changes have been destabilizing … from a universe essentially marked on equality, homogeneity, objectivity, substitutes a world marked by heterogeneity, plurality of logics and subjectivity. " [9] In this note, Giust-Desprairies underscores differences between teachers worlds and students worlds. The teacher is preoccupied with the objective world of content coverage, grades, accountability, classroom attendance. In contrast the adolescents are preoccupied with experiencing life, their place in society, immediate social setting.

Given this uncertainty for life in the 20° Century and the difference in teachers and students view of the world, we must not ask students to learn Biological concepts in decontexualised situations. Instead we have to give them the capacity and the confidence to use their knowledge to solve their problems: "to be able to fashion and refashion their "tools" for living and working as different challenges and opportunities emerge and change throughout their lives. "

4. How to prepare future teachers to be aware of and to implement an integrative understanding of Biology Teaching in their teaching?

I will not describe the whole Biology Teacher Education curriculum currently developed in Louvain-la-Neuve. I only will describe one activity proposed to the future teachers in order to lead them to experience these new directions in Biology teaching. The assumption is that if they experience these new directions, they will be capable of implementing them into the secondary school.

My purpose now is to illustrate how we can translate " principles " of integrative Biology Education into teacher education activities. In the following part, I will describe one activity for future Science teachers at the Catholic University of Louvain. Then I will show the results of this type of activity.

4.1. Context

Each year, for one week, the UCL Faculty of Science organises what we call " Science Fair ". Students and teachers from all school levels participate to an " hand-on science experience " in LLN. These activities are prepared by members of the Faculty of

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[8] Guy Claxton " Science of the times. A 2020 vision of education " In Ralph Levinson , Jeff Thomas *Science today*. London, Routledge 1997 p. 76

Science. This year, the future teachers[10] have been asked to construct activities they would implement for upper secondary school students.

The topic was: " Biology, Chemistry and Physics at home ". The future teachers were divided into groups. Each of them chose a room in the house : kitchen, storeroom, bathroom, laundry and garden. The task was, for the future teachers, to assist secondary school students understanding some everyday phenomena, that can best be understood through scientific concepts

→This project is designed to prepare future science teachers to

- integrate scientific knowledge into everyday life
- start from problems, questions.
- move from disciplinary-based-learning to problem-based-learning.
- give another meaning to the concepts they teach: from "science per se" to "science to be used for finding out how our knowledge works in our everyday life".
- move from strict disciplines to interdisciplinarity.
- move from passive to active learning
- move from acquisition of knowledge separate from usage to acquisition throughout usage
- move from individualism to team work

Let's see now how the students responded to the task. Helping the student teachers to understand the task turned out to be challenging. At first they did not understand the task. Thus this one evolved during the semester.

In the following section, I will describe how the task evolved over the course of the semester.

4.2. Stage one of the task

The task

The first task we gave to the student teachers was to name five examples, objects, phenomena, which, to be explained, understood, use experimental sciences. Student teachers were asked to give a first scientific explanation of them.

Students production

The result of this assignment was disappointing. The following example shows the results of the assignment : the student teachers only named scientific concepts without giving any explanation.

- Chloride in the swimming pool
- Swimming, one floats P /weight
- Garden : plants in relationship to the soil
- Fish breathing
- Birds : anatomy and comparison with mammals
- Photosynthesis
- Rocks and soil formation

Comment

We can see from these results that students are far away from being able to give a scientific explanation, resting on interdisciplinarity. They rather view the “theoretical point of view”.

The students themselves stated that this kind of work was different from their usual way of seeing science and that they missed knowledge to tackle the task. They were asked to do more research so that they would feel better prepared.

4.3. Stage two of the task

The task

Student teachers were asked to present their former work updated with the knowledge they would have found.

Students production

The student teachers arrived with a display showing the water and nitrogen cycles. Their presentation illustrated the concepts of photosynthesis, perspiration, erosion.

The student teachers reported that they intended to give the secondary school students the board with the cycle drawn on it but without the concepts. The concepts would be written on tags that the secondary school students would be asked to put “at their right place”.

Comment

Stage two did not move the student teachers from their theoretical perspective.

It seemed as if their search for more understanding of the phenomena resulted in “decontextualised theory”. In order to assist them to move from this point of view to the new directions I have spoken about, we asked them to “prepare a performance”.

4.4. Stage three of the task

Task

The students were asked to think about how they would generate a garden like environment in a classroom. They were also asked to formulate questions or problems they would work on with the secondary school students. These questions had to address different scientific aspects (Biology, Chemistry, Physics) and be linked with everyday life that happens in gardens.

Students production

The stage setting prepared by the student teachers was composed by a reconstructed garden, a plan showing a garden project, two posters : one explaining allergy, another explaining the Nitrogen cycle and tables showing criteria that influence life of different plants (texture and composition of the soil, orientation,…).

The story was: Mr and Mrs X plan to “re-design” their garden. They want to plant different trees and to take the nettles away from the garden. One of the question was “how to decide what to plant and what influences their growth?”

Comment

This final production showed very clearly that, at this point in the process, the students teachers brought scientific concepts to answer questions. For example, in order to understand why trees grow well in certain places and not in others, the student teachers had to deal with interdisciplinary issues. For example issues that included Hydrology, Climatology

4.5. Fourth stage of the task:

During this stage the student teachers were asked to work with secondary school students and to put into place all of the elements of the three first stages of the task. This step reflected everything that the students had prepared.

5. As a conclusion : de-briefing: what the students have said about the activity?

The last step of this activity was a de-briefing. Even though in each step, the students were placed in a "meta" position, this final one aimed specifically at looking at the learning they did during this activity.

During the debriefing, the first thing they reported was that they had felt what is "to work" in team rather individually. It joins our observation: the first production had no coherence in itself. We felt different ideas put together rather than "thought" together. They also pointed out that this kind of work taught them to work with unforeseen situation. We hoped that, with this kind of exercise, they will learn to manage uncertainty. They also said that they felt a change in their way of seeing the link "practice-theory".