

Outlines and outcomes of educational research: the scientific and the societal relevance of the theme 'reproduction' with regard to biology teaching in secondary schools in Belgium (Flanders)

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SUMMARY

The research project aimed at evaluating the biology curriculum in the perspective of a current education renewal.

First, for the theme 'reproduction', a frame of reference was designed. It contained the description of the core of biological knowledge by mapping biological concepts, formulating important biological generalisations and determining relevant concepts by means of a content analysis of newspapers. In addition, more aspects of the pupil-orientated dimensions were added through a study of literature on puberal development and behaviour. Subsequently a sophisticated analysis instrument with a descriptive and a normative function was derived.

Second the scientific and societal relevance of the actual textbooks and curriculum documents was analysed and evaluated with focus on: learning objectives, common and specific biological generalisations, important biological concepts including affiliated contexts. It pointed out several gaps and shortcomings in textbooks and curriculum documents.

Third a blueprint for a series of lessons was designed to improve the scientific and societal relevance of the school subject. The elaboration of the lessons and the explanations are meant as a support for curriculum and textbook development with hints about aims, learning objectives, target groups, content, structure and methodology.

KEY-WORDS

curriculum analysis, textbook analysis, biology education, concept map, context, generalisation, teaching objective, educational research

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Introduction

This presentation is a brief report of a Ph.D.-research project with regard to the educational relevance of school biology in general secondary education (Algemeen Secundair Onderwijs, ASO) in Flanders. It fits within an evaluation of school curricula and the determination of educational goals and attainment targets by the educational authorities.

The project can be approached as an exemplary study that shows some methodological features of educational research supporting the continuous efforts to match education with the ongoing changes in the outer world. For the complete report (in Dutch with summary in English) we refer to the footnotes (1).

Set up of the research project and thinking about biology education

The central problem stated in the study is: *'What is the scientific and the societal relevance of biology teaching in general secondary education in Flanders with regard to the theme reproduction, and how the relevance might be increased if necessary?'*

In educational research it is often inevitable to handle a view on learning and education. As already stated, school biology in general secondary education has a scientific and societal function. The scientific function is that pupils acquire relevant biological knowledge about the structure and function of the human body and of the living nature, including a biological view of mankind. The societal function is that pupils can recognize biological aspects within social and personal situations and that they are able to apply relevant biological knowledge to these situations.

The school subject biology originates from a well-considered and socially accepted selection of biological knowledge. Moreover, a biological point of view is important to retain and to obtain an internal coherency within a biology curriculum. In this educational investigation an organism is considered as an 'autopoietic' system with a number of fundamental properties, among which the ability to reproduce itself. Equally important is the choice of a point of view on learning and teaching. In this study constructivism is chosen, i.e. learning is considered as an active construction process in which a pupil links new information with previous knowledge. Using real-live problems in an educational context will stimulate this process.

The investigation aimed at evaluating the present school subject. It is a curriculum evaluation based on the curriculum documents and the textbooks of the two major competent educational authorities in Flanders. These supervising institutes are the 'Vlaams Secretariaat voor het Katholiek Onderwijs (VSKO, private Catholic schools)' and the 'Autonome Raad voor het Gemeenschapsonderwijs (ARGO, public maintained schools)'. Given the multitude of possible branches of study, biology education was only investigated for those curricula the majority of the pupils are confronted with: the so-called minimum curriculum and the zero-hour-curriculum. In the latter, there are school years, in which no biology is taught.

The investigation was executed in three phases. First, for the theme reproduction, a frame of reference was designed, from which a curriculum analysis instrument with a descriptive and a normative function was derived. Next, the actual educational situation was evaluated for both the scientific relevance and the societal relevance. As could be expected, the evaluation pointed out several gaps and shortcomings in textbooks and curriculum documents. Finally a blueprint for a series of lessons was designed to improve the scientific and societal relevance of the school subject.

A versatile frame of reference to an analysis instrument

In order to set up the frame of reference, the first phase of research was separated in several subordinated but interrelated investigations. Below they are listed in the order they were carried out.

(a) Concept maps to determine a formal structure of biological knowledge

In a preliminary study 61 concept maps are made. In total these maps contain up to 458 important biological concepts and their interrelations, with regard to the theme reproduction. The concept maps are an elaborated visualisation of the general biological knowledge and are a 'formal structure' of the theme 'reproduction'. It is an important tool for some of the subsequent investigations, especially those in which the adequate formulation of important biological generalisations are under discussion.

Since making and discussing a concept map is an important metacognitive activity, it strongly supported the researchers in activating and extending their own biological knowledge.

(b) Important biological generalisations to construct an educational structure of biological knowledge

Based on the concept maps, 15 important formal biological generalisations were carefully composed. A generalisation is one or more combined propositions each on their turn made of keyconcepts and their relations. Formal biological generalisations make up the backbone or 'educational structure' of biology and fulfil an important integrating function in the cognitive structure of pupils. When formulating the generalisations special attention was given to both the descriptive and the explanatory biological generalisations. The explanatory causal and functional relations among concepts are after all important for stimulating the process of 'learning to think in a biological way'.

(c) Content analysis of newspapers to determine societal important biological concepts and their context

Content analysis of all seven important newspapers in Flanders, spread over one year, made it possible to determine (1) the societal importance of biological concepts with regard to reproduction, and (2) the contexts in which they appeared. The content of 811 relevant articles with in total 1911 biological concepts was screened. The methodology was completely based on research protocols suitable in social sciences. Depending on their significance the observed concepts were condensed to 358 keyconcepts classified into five manageable groups. The observed contexts were classified in terms of 55 context categories, of which also the relative importance was determined.

(d) Analysis of literature for pupil-orientated biological knowledge and contexts

Study of literature supplied information concerning the personal or pupil-oriented dimension of the frame of reference. It concerns: data about the puberal development; recent surveys on the sexual behaviour of Flemish pupils; governmental guidelines and directives of educational authorities within the scope of relational and sexual education (RSE) at school.

The most important yield of the analysis is an inventory of RSE-topics related to biological knowledge and an optional timetable for biological topics related to sexual behaviour throughout secondary school years.

(e) Specific biological generalisations to construct an educational structure of biological knowledge

Subsequently eighteen specific biological generalisations were composed. The characteristics

specific biological generalisations are subordinated to the above-mentioned generalisations. But the specific generalisations contribute to the knowledge of and the insight in specifically societal topics. On the basis of the preceding content analysis (stipulation of important contexts) it was opted to limit them to the reproduction of man, the reproduction of flowering plants and biotechnology (reproduction technology). The marking of the societal relevant keyconcepts (content analysis) in the concept maps was of substantial support to formulate the specific biological generalisations.

(f) A set of favourable broad teaching objectives for biology education regarding the theme 'reproduction'

Finally six favourable teaching objectives were formulated, based on the view of learning and teaching, and based on the other elements of the frame of reference. These aims were circumscribed as reference objectives and were ordered in two groups, namely three scientific-orientated and three societal-orientated reference objectives. The last-named include a time limit for RSE-topics.

From a frame of reference to an analysis instrument

Finally, a curriculum analysis instrument with both a descriptive and a normative function was derived. For practical reasons this is split up in six components, each referring to the evaluation of the curriculum documents (*) and/or textbooks with regard to the theme 'reproduction'.

In general, the descriptive function can be realised by literally scoring the presence of generalisations, concepts and contexts in both textbooks and curriculum documents. The normative function deals with the scientific and societal relevance of textbooks and curriculum documents by assessing the extent of coverage of the preconceived teaching objectives, generalisations, concepts and contexts.

The analysis instrument is subdivided in six separated units.

Analysis unit 1: Scientific orientated reference objectives

- Three objectives (in brief): (1) enable pupils to construct a framework of important biological generalisations —about the process of reproduction- that will serve long after; (2) enable pupils to get a grip understanding of the process of science included science as a social-embedded process; (3) enable pupils to appreciate or value science.
- Objectives in the curriculum documents can be assessed by interpretation and comparison.
- When all three reference objectives are completely or greatly covered, the curriculum can be considered as scientific relevant.

Analysis unit 2: Formal biological generalisations

- 15 formal biological generalisations. Each of them clearly separated in the composing propositions and their descriptive or functional orientation.
- Propositions in textbooks and content outlines in curriculum documents can be assessed by comparison and scoring.
- Depending on the coverage a curriculum or textbook can be considered to have a low, insufficient, sufficient or high scientific relevance.

Analysis unit 3: Scientific orientated reference objectives

- Three objectives (in brief): (1) enable pupils to construct a framework of biological generalisations —about human reproduction, anti-conception and sexual transmitted diseases (STD including AIDS)- that will serve long after; (2) enable pupils to identify biological principles (reproduction of man and other organisms) in the context of the daily life and to apply their knowledge towards a motivated opinion and decision; (3) enable pupils to apply their knowledge (STD and unexpected pregnancy) towards a motivated opinion and discussion.
- Curriculum objectives can be assessed by interpretation and comparison.
- When all three of them are completely or greatly covered the curriculum can be considered as societal relevant.

Analysis unit 4: Specific biological generalisations

- 18 specific biological generalisations. Each of them clearly separated in the composing propositions and their descriptive or functional orientation.
- Propositions in textbooks and content outlines in curriculum documents can be assessed by comparison and scoring.
- Depending on the coverage the curriculum or textbook can be considered to have a low, insufficient, sufficient or high societal relevance.

Analysis unit 5: Societal important concepts

- Based on the content analysis a list of important concepts can function as a checklist (composed of three groups: aberrant high frequent, first and second quartile).
- The treated concepts in the textbooks can be assessed by scoring.
- Depending on the coverage the textbook can be considered to have a low, insufficient, sufficient or high scientific relevance.

Analysis unit 6: Societal important context

- Based on the content analysis a list of societal important contexts, extended with context derived from the RSE-survey, function as a checklist.
- Textbooks and the outlines in curriculum documents can be assessed by interpretation and scoring. The latter including the elaboration or instructional approach of a context, i.e. only illustration or for teaching/introducing subject matter or for the application/transfer of knowledge.
- Depending on the coverage the curriculum or textbook can be considered to have a low, insufficient, sufficient or high scientific relevance.

Each analysis unit can operate independent and generates a partial answer for the central problem. Nevertheless the results will interlock and need integration to give a final answer.

The assessment of 'reproduction' in biology education in Flanders

Since the results of the study must be seen in close relation to the educational field in Flanders a comprehensive discussion goes beyond this presentation. Nevertheless a brief review to show the versatility and flexibility of the analysis instrument.

Scientific relevance

We can conclude for the VSKO (Catholic school authority) that the theme reproduction concerning scientific relevance is insufficient. The curriculum objectives point at the acquisition of biological knowledge, but hardly give any attention to the knowledge of and the insight in science as a social enterprise in a societal context. The appreciation of scientific biology in terms of its cultural and non-utilitarian significance is also stressed insufficiently. Too little common biological generalisations are mentioned when paraphrasing the subject matter of the curriculum documents. Although the subject matter is present to a sufficient extent in textbooks, the related generalisations are not consistently introduced in the topical passages.

We can conclude that the theme reproduction is insufficiently relevant for the ARGO (governmental education authority) as well. Concerning the curriculum objectives we reach the same conclusion as for the above-mentioned supervising authority. On the other hand it is indicated explicitly in the curriculum documents, that for the acquisition of biological knowledge the explanatory approaches in biological generalisations are important. The number of common biological generalisations appearing in the paraphrases of the subject matter of the curriculum documents is too little. The subject matter is sufficiently present in the textbooks, but the generalisations aren't consistently introduced in the topical passages.

Societal relevance

We can conclude for the VSKO that the societal relevance for the theme 'reproduction' in biology is insufficient. Apparently the timing of the subject matter in the curriculum objectives isn't optimal. In the first grade (13-14 years) the topic of reproduction of man is treated briefly, and extensive attention is only paid to it in the third grade (17-18 years). Besides, the aspect of sexuality gets little or no attention. Topics like sexually transmittable diseases and contraception appear in the third grade. The objectives prove that the subject matter with respect to the reproduction technology is limited to man. Relating knowledge to societal contexts, with the exception of bio-medical problems, gets little attention as well. With regard to the specific biological generalisations, the definitions of the subject matter in the curriculum documents appear to be sufficiently present, with the exception of the subject matter about reproduction technology. Generalisations as mentioned above appear too little in the topical passages of textbooks. If generalisations occur, then the mentioning of explanatory relations is paid insufficient attention to. The objective concerning 'learning to think in a biological way' is not stimulated enough. After a quantitative assessment sufficient societal important concepts are detected in the textbooks. But after a qualitative assessment we notice a gap. A lot of concepts about the reproduction of man, human sexuality and health are lacking, or they are for the first time introduced in the third grade. Of course this is linked to the choice of the curriculum objectives. The observed use of contexts in textbooks is also related to the objectives, but the use is especially limited to the illustration of the subject matter. For the pupils to acquire and to apply knowledge, these contexts are not elaborated enough. And little importance is given to a number of societal important context areas, such as puberty.

For the ARGO we can conclude that the school subject biology has enough societal relevance regarding 'reproduction'. Although some weaknesses have to be pointed out. From the curriculum objectives we deduce that the subject matter with regard to the reproduction of man is treated sufficiently in the first grade, as planned in the reference objectives. Yet, topics such as sexually transmittable diseases and contraception, including the importance of

to societal contexts is present in the objectives in the curriculum documents, but the concrete elaboration is not mentioned. In connection with the specific biological generalisations we can draw the same conclusion as for the above-mentioned supervising institute. The number of societal important concepts in textbooks is sufficiently present. After a qualitative assessment a small gap with regard to the reproduction of man, human sexuality and health is noticeable. In the textbooks a whole range of context areas is mentioned, but the educational application of contexts is mainly restricted to the illustration of the subject matters.

A blueprint with elements for curriculum renewal for the theme 'reproduction', including a series of lessons

The research project is finalised with a blueprint for curriculum renewal. It is set up as a series of lessons. The main points of the blueprint are tuned to the perceived shortcomings during the analysis. The elaboration of the series of lessons and the explanations are meant as a help for educational development with hints about objectives, target groups, content, structure, methodology and possibilities to implement the lessons in present school biology. Important features of renewal, which can contribute to the improvement of the scientific and societal relevance of school biology, can be found in the objectives of the series of lessons. Here we focus on: the acquisition of knowledge and insight in a number of important biological generalisations; the understanding of the processes and the nature of science; the appreciation of biology as a science; the recognition of biological aspects in a societal context; the integration of relational and sexual education in school biology. In the teaching approach the emphasis is on the activation of previous knowledge; the use of appropriate learning contexts; the application of biological generalisations with descriptive and explanatory connections to promote biological thinking. In view of a small-scale investigation the blueprint was tested on its practicability in school. Evidently, it can be an initiative to remedy the relevance of school biology in the VSKO. With regard to the ARGO, organisational and normative resistance was noticeable, especially in those lessons dealing with aspects of relational and sexual education.

Conclusions

With regard to the BioEd 2000 Symposium, one can focus on methodological solutions towards a better biology education in the near future. One of the important outcomes of the presented research project is a complex analysis instrument to evaluate biology curricula and textbooks. Retrospective analysis during testing and implementation of the different units proved that the results were reliable and valid. In practice the analysis instrument showed to be flexible and versatile. Beside a general ordeal about specific curricula and textbooks a more important outcome of the analysis is a detailed description of the different points of weakness of curricula and textbooks towards a better societal and/or scientific relevance of school biology. Educational authorities, curriculum developers and textbook writers, and teachers welcome such results.

(1) Patrick Reygel, *Het thema reproductie in het schoolvak biologie*. Utrecht, CD-beta Press, 1997.

(2) A so-called 'leerplan' is a curriculum document with detailed description of content, teaching objectives and suggestions for learning strategies and the use of learning resources

