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# Occurrence and Representation of Evolution in Austrian Biology Textbooks

**Martin Scheuch[1], Martin Wäger[2]**

## Abstract

*Evolution is the central theory of biology; therefore it should be used as a guiding idea in biology school textbooks to construct cumulative learning pathways for the students. To test this assumption, 17 biology textbook series (mostly in their entirety: n=63) which are approved for use in lower and upper secondary education (for students from 10 to 18 years) in Austria were analysed. For that purpose, a set of categories, including some of the most important concepts and mechanisms of evolution was developed: e.g. adaptation, population. Those were applied in a qualitative content analysis. In a second step the occurrence of these concepts was quantified to enable comparisons between the textbooks of one single grade and the whole textbook series. In this contribution we show two exemplary results: the use of the term ´adaptation´ with or without evolutionary context and the occurrence of ´population´ during the whole secondary education. While the first example is about a linguistic and not precise use of the term ´adaptation´, the latter example shows that a key concept for understanding evolution is nearly missing in the textbooks. These two examples reflect the situation of evolution education via textbooks in Austria. This is not only the fault of the textbooks but is rooted in the state curriculum where evolution is only mentioned in grade 7 and 12. Therefore the textbooks already compensate parts of this deficiency in including concepts in other grades, but on the other hand also fail to build up consistent learning pathways either. Therefore, evolution is treated more as an isolated subject instead of being seen as a superordinate idea.*

**Keywords:** *Evolution, Biology textbook analysis, Austria, state curriculum, cumulative learning*

## 1. Introduction and Theoretical Background

Biology textbooks are guiding material in biology education in schools. A study in the US [1] from 1989 states that 75 to 90% of the classroom based instruction is based on textbooks. This may have changed due to internet and computer technologies but textbooks still have their role, especially for realizing the state curriculum. Therefore the textbooks have been objects of research in biology education and especially with the focus of evolution [2, 3, 4, 5, 6]. One critique which results from this research is drastically coined by the following quote: *"When organic evolution is avoided, biology is reduced to a rubble [sic.] of meaningless facts.*" [7, p.19]. Often Evolution is not avoided but treated as an isolated topic [4, 5, 6], and also introduced only at the end of schooling [2, 8]. This is a point, which the textbook authors cannot be blamed for but the state curriculum prescribes when evolution has to be taught [8]. In Austria this is the case: evolution is scheduled in grade 7 (13 year olds) as "history of life" without mentioning evolution explicitly and then again mentioned explicitly in grade 12 (18 year olds) [9, 10]. Therefore the state curriculum does not recognise the centrality of evolution as the most important and underpinning theory for the whole field of biology. In the last 20 years a lot of endeavours were made to develop curricula that help the students learn and build up their knowledge continuously. One attempt are learning progressions [11, 12] where the state curriculum is planned in such a way, that students' perspectives and learning are seriously taken into consideration in planning the sequence. One example of realization is the Next Generation Science Standards in the US (https://www.nextgenscience.org/). As there are a lot of studies about textbooks in other countries like Spain, Brazil, the US, late USSR and China [3, 4, 8], but we do not know the current Austrian situation, we conducted an exploratory study. Our research questions therefore are:
How is evolution represented in biology textbooks for lower and upper secondary schools in Austria?
Can we infer that the displayed concepts are in line with the idea of learning progressions?

## 2. Material & Methods

In total we analysed 63 textbooks from 17 textbook series. For the lower secondary schools (level 5 to 8 for 10 to 14 year olds) we analysed 14 series (mostly complete, except those that were not fully published at the time of analysis) and 52 textbooks. In upper secondary schools (only Gymnasium, no

[1] University College for Agricultural and Environmental Education, Austria
[2] University of Vienna, Austria

higher vocational schools included) we included 5 series and 15 textbooks (levels 9 to 12 for 15 to 18 year olds).
The methodology was a qualitative content analysis [13] with predefined categories which can be found in table 1.

| CATEGORY | DEFINITION (only given for some categories) |
|---|---|
| Variation | Overall Information:<br>Apply if variation/differences BETWEEN individuals is mentioned<br>DO NOT apply it for the resulting variability.<br>Linked variation with sub categories of different forms of selection |
| Selection natural | … |
| Selection artificial | … |
| Selection sexual | … |
| Adaptation | Word “adaptation” found in evolutionary context |
| Adaptation unspecific | Word “adaptation” found in not evolutionary specific context |
| Population | … |

Table 1: Central categories of evolution for the analysis. Each category was precisely defined (only displayed for some examples in column 2).

In all textbooks these categories were applied and all sentences, where those concepts showed up, were extracted and further coded (which chapter, which level, context) in the software MaxQDA12. A similar method with counting concepts was developed by Skoog [2]; we added further ideas to our methodology inspired via Moody [5] of “how a topic functions” and a more elaborated methodology of textbook coherence by Roseman et al. [14]. The display of the results is a simplified word count per schoolbook and per series.

## 3. Results

In total those categories were applied for 1447 times with ´adaptation´ in an evolutionary sense being the most commonly used and ´sexual selection´ being last (see table 2).

| CATEGORY | FREQUENCY |
|---|---|
| Variation | 214 |
| Selection natural | 115 |
| Selection artificial | 347 |
| Selection sexual | 32 |
| Adaptation | 365 |
| Adaptation unspecific | 232 |
| Population | 142 |

Table 2: Frequencies of the categories assigned to the textbooks

One exemplary result is that in lower secondary textbooks the term ´adaptation´ is the most common; this term was found on 421 pages; 278 times with evolutionary context as well as without evolutionary context on 143 pages (14 series & 52 textbooks). In upper secondary textbooks the respective counts for ´evolutionary adaptation´ is 87 and 89 for ´unspecific adaptation´ (5 series & 15 textbooks). Two quotations illustrate the difference: ´adaptation evolutionary´ “*Moles are adapted to life below ground.”* (level 5, code 3) and ´adaptation unspecific´ *“The female body adapts during pregnancy to this new situation.”* (level 8, code 21).
A second result is the nearly complete absence of ´population´ in lower secondary textbooks, only found on 17 pages without any or wrong definitions (14 series & 52 textbooks). Only in upper secondary textbooks (5 series & 15 textbooks) the term ´population´ can be found on 127 pages with an increasing frequency from level 9 (8 pages) to level 12 (75 pages). But even then, definitions are scarce and sometimes not correct with respect to evolutionary processes; only in three textbooks the evolutionary context of ´population´ is explicitly explained. Two examples of the use of ´population´: “*A smaller number of field mice effect the population of buzzards.”* (level 7, code 44), “*Artificial selection effects a rapid change of a population; population is the entirety of individuals of a species in a certain area which can reproduce.”* (level 12, code 64).

## 4. Discussion and Outlook

´Artificial selection´ with its context of breeding, domestic animals and plants is thrice frequent compared to ´natural selection´. We think this is adequate, because breeding as an example can help students to understand a selective process and that not every individual reproduces. A problem could be that a human breeder acts goal oriented and this is counter intuitive to natural selection, where teleological thinking is an obstacle in understanding. This is supported by the research on student´s conceptions [10, 14]. This was also one critique of Aleixandre [4], that textbooks fail to work with students´ previous concepts in general and often deterministic or teleological language in textbooks even support these previous understandings and hinder learning.

Careless use of the word ´adaptation´ in evolutionary as well as unspecific context may cause another serious problem. It is assumed, that students are confused by this unclear use of the same term. The examples show that once it is used at an individual level, often describing intended and goal directed actions without evolutionary context. But the same term is used to describe the result of evolution, where the meaning is that a population or species has acquired features that fit it into the actual environment. Besides that ´adaptation´ is a problematic evolutionary concept itself, this dual use is more than problematic for learners, if you intend to explain evolutionary development.

´Population´ is an even more important concept for understanding evolution, because in populations the frequencies of genetic traits change over generations due to ongoing selective processes and differing reproduction. Thus our result is an alarming one, because the books do not introduce the concept as early as other concepts and even do not define it properly.

Somehow, the textbooks compensate the failure of the state curriculum by introducing evolutionary concepts in all levels, but at the same time do not build consistent learning pathways for the students. Therefore, evolution is treated more as an isolated subject in level 7 and 12 and the single concepts occur by chance in any level. Evolution is not being seen as a superordinate idea and a meaningful guideline during the whole secondary biology education.

Our next plans are to analyse selected series with the learning progression concept [14] and look more closely at the development of the single concepts over the years.

## References

[1] Woodward, A., Elliott, D.L. “Textbook Use and Teacher Professionalism”, Textbook and Schooling in the United States (Elliott, D.L., Woodward, A. Eds.), Chicago, National Society for the Study of Education, 1989, 14-17

[2] Skoog, G. “Topic of evolution in secondary school biology textbooks: 1900-1977”. Science Education, 63(5), 1979, 621-640

[3] Swarts, F. A., Roger Anderson, O., & Swetz, F. J. “Evolution in secondary school biology textbooks of the PRC, the USA, and the latter stages of the USSR”, Journal of Research in Science Teaching, 31(5), 1994, 475-505

[4] Aleixandre, M. P. J. “Teaching evolution and natural selection: a look at textbooks and teachers” Journal of Research in Science Teaching, 31(5), 1994, 519-535

[5] Moody, D. E. “Evolution and the textbook structure of biology”, Science Education, 80(4), 1996, 395-418

[6] Nehm, R. H., Poole, T. M., Lyford, M. E., Hoskins, S. G., Carruth, L., & Ewers, B. E. “Does the segregation of evolution in biology textbooks and introductory courses reinforce students' faulty mental models of biology and evolution?” Evolution: Education & Outreach, 2(3), 2008, 527-532

[7] Tyson, H., & Woodward, A. “Why students aren’t learning very much from textbooks” Educational Leadership, 47(3), 1989, 14-17.

[8] Tidon, R., & Lewontin, R. C. “Teaching evolutionary biology”, Genetics and Molecular Biology, 27, 2004, 124-131

[9] Scheuch, M., Amon, H., Scheibstock, J., & Bauer, H. “"Evolution - Ein Roter Faden fur die Schule" - Kumulatives Lernen von Variation und Selektion in Sekundarstufe I und II” plusLucis, 1, 2017, 14-18.

[10] Scheuch, M., Amon, H., Scheibstock, J., & Bauer, H. “Teaching Evolution along a Learning Progression: An Austrian Attempt with Focus on Selection (Chapter 5)”, In M. Reiss & U. Harms (Eds.), Evolution Education Re-considered: Understanding what works, Springer, accepted, pp. 17

[11] Duncan, R. G., & Rivet, A. E.”Science Learning Progressions”. Science, 339(6118), 2013, 396-397

[12] Duschl, R., Maeng, S., & Sezen, A. “Learning progressions and teaching sequences: a review and analysis”, Studies in Science Education, 47(2), 2011, 123-182

[13] Mayring, P. “Qualitative Inhaltsanalyse. Grundlagen und Techniken” Weinheim und Basel: Beltz Verlag, 2007
[14] Roseman, J. E., Stern, L., & Koppal, M. “A Method for Analyzing the Coherence of High School Biology Textbooks” Journal of Research in Science Teaching, 47(1), 2010, 47-70
[15] Scheibstock, J. “Lerneffekte im Unterricht zum Thema Evolution - eine Untersuchung zur Entwicklung von SchülerInnenvorstellungen zu Selektion und Variation”, Universität Wien, Wien, 2014, 180