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# Teaching Evolution with Austrian Biology Textbooks

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## Abstract

*Evolution is the central theory of biology; therefore it should be used as a guiding idea in biology school textbooks to construct meaningful learning progressions for the students. This study is a qualitative follow up study with the focus on two widely used biology textbook series in lower and upper secondary schools in Austria. In the previous study 63 biology textbooks of 17 available textbook series were analyzed. Two exemplary results there were the sloppy use of ´adaptation´ as one of the most common terms with and without evolutionary context. The other one is the nearly complete absence of the term and the concept of ´population´. The main research interest in the present study was the following: how are the evolutionary concepts in the textbooks linked to each other horizontally (within one textbook) and vertically (between textbooks of different grades of the same series). The coding was guided by a concept map which linked the core evolutionary concepts (like variation, selection, population etc.). We started with the NGSS strandmaps as potentially meaningful learning pathways to construct the concept map. This concept map was then the guideline for analyzing first and then depicting the results from grade 5 to 12. One exemplary result is the prevalent fragmentation of the concepts during the compulsory school years. Especially in lower secondary grades only artificial selection is presented in a satisfying manner, all other concepts occur occasionally but not linked to each other or are totally left out (e.g. population). Another result is the misleading presentation of natural selection. The fact that natural selection selects at the individual level but the results can only be seen at the level of populations over the generations is not represented; the causes and effects are mixed up. This is problematic, because adaptation is very often seen at an individual level – this is a prevalent teleological and anthropomorphic student´s concept and the textbooks even strengthen this concept instead of opposing it.*

**Keywords:** *Evolution, Biology textbook analysis, Austria, learning progression, concept map;*

## 1. Introduction, Theoretical Background and Research Aims

Evolution education, which includes teaching and learning about evolution, is very demanding for all involved: teachers and learners. Moreover, as it is a theoretical pivot point of modern biology and therefore key for understanding biology as a scientific discipline, a lot of biological phenomena and processes, can only be understood with evolutionary background knowledge [1]. Textbook in schools are an important source for learning, it is even said that textbooks are the secret curriculum [2]. But how can textbooks help in learning evolution? A few studies at hand [3, 4, 5, 6] showed several findings for different countries. Some of the studies found out that evolution is often treated in an isolated way [3, 4, 5] a resulting critique is that evolution cannot serve its universal function of an explaining theory. In Austria the curriculum in secondary schools mentions evolution only twice [7, 8, 9], nonetheless in an analysis of the most common textbooks (63 books from 17 series) it could be shown, that books can compensate this lack of the curriculum, although they create other problems [8]. For example the use of the concept of adaptation was found highly problematic as well as the population concept, which was found very seldom and fragmented itself [8].
This study is a follow up analysis where two textbook series from lower and upper secondary schools that are most commonly used were analysed in a qualitative study for the coherence of the topic evolution and its single concepts.

### 1.1 Learning Progressions

Textbook analysis can be done in many ways. This contribution follows the theoretical background of learning progression (LP) [10, 11, 9]. In this framework for LPs cumulative learning means gradual cognitive development of conceptual knowledge. As evolution is not only one concept but encompasses several interlinked concepts (population, reproduction, heredity, variation, different forms of selection, time) coherence of learning content and the sequence of the single concepts play an important role for possible learning pathways [12]. In a carefully planned LP about evolution

learning can take place by learning this related set of concepts step by step over the years. One good source of LPs for a lot of science topics are the so called strandmaps, which were developed after the release of the "Next Generation Science Standards (NGSS)" in the United States [13]. Therefore it is important to look at textbooks whether the single concepts are linked horizontally (within one textbook) or vertically (between the textbooks of the different grades) to get an impression of textbook coherence [14].
Our research aim is to deepen the knowledge about the coherence of the concepts and the overall topic of evolution within two selected biology textbook series for lower and upper secondary schools.

## 2. Material and Methods

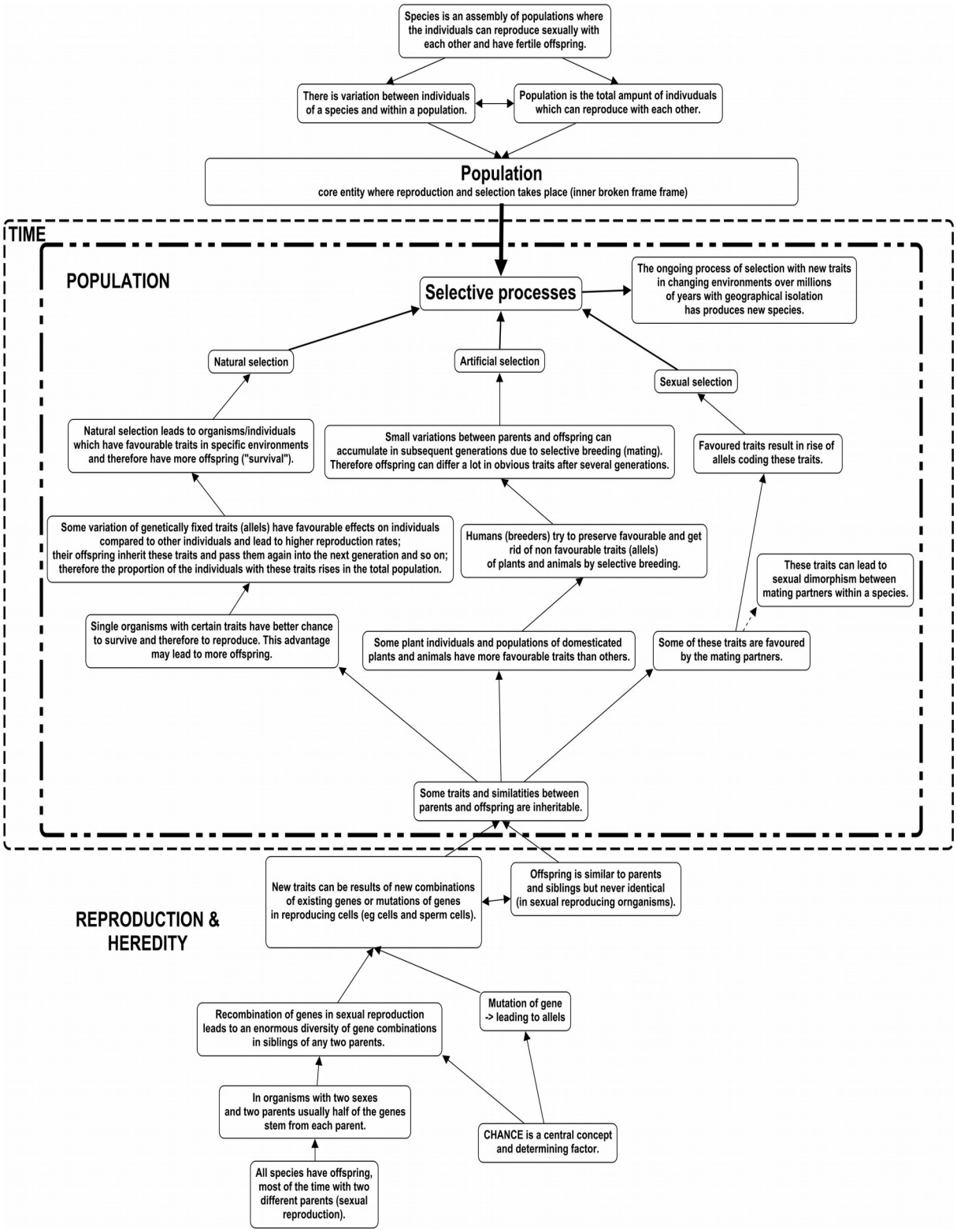
A previous study took 17 biology textbook series with 63 textbooks and made a qualitative content analysis with predefined categories which were the central concepts of evolution [8]. For the recent study two series [15, 16], with seven textbooks each, were selected. Criteria were that the series includes lower and upper secondary grades and that these books are widely used. In Austria the two chosen are under the three mostly used series in the whole secondary level [17]. In the 11$^{th}$ grade in most school types there is no biology taught, therefore there are no textbooks available. Overall the methodology followed the procedure of a study of Roseman et al. [12]. The topic analysed is arranged in a hierarchical concept map following the logic of a LP, where the single concepts are linked for coherent and assumed learning pathways. For the analysis of evolution in those biology textbooks the categories of the previous study [8] were taken and the corresponding strandmaps of the NGSS [13] ("heredity" and "biological evolution") were used to construct a concept map as a blueprint for analysis, applied as steps of a qualitative content analysis [18]. Additional information came from literature about learning evolution to create a sequence of concepts. This concept map (see Fig. 1 in the results) was then applied to each individual textbook and only appearing concepts and the respective links were left, all others were deleted. One coding entity was the whole concept, not only the single words without evolutionary context. Therefore each resulting concept map shows the treated concepts of the respective grade.

## 3. Results & Discussion

### 3.1 Learning Progression of Evolution – the tool for analysis

In Fig. 1 (see below) the concept map is shown. The concepts were translated and simplified for this contribution. In the original map the concepts were coloured and their links are displayed with arrows. Those arrows show the planned direction of LPs. The two broken boxes frame those concepts where the concept of "deep time" (outer box) is crucial as well as the inner box, which stands for processes within populations.
This concept map helped to structure the single concepts found in the textbooks and made visible whether they were linked or not. A colour coding system (not showed in this contribution) made it possible to combine the concepts into one overview to make repetition of one concept in consecutive textbooks visible.

Fig. 1: Learning Progression for Evolution. The concepts are linked in a hierarchical scheme.



### 3.2 Exemplary Results and Discussion

The concept of time was not well represented in the textbooks. Only a few times and associated with small concepts (e.g. artificial selection) this issue was explicitly mentioned in one series [16], while it was more included in the other series [15], but mainly in upper secondary grades. In both series are the huge time spans really applied in grade 12, only at the end of the school career. In an overview of the five textbooks of compulsory schooling (in Austria up to the age of fifteen or grade 9) this can be seen, because time issues are only broached along two small concepts dealing with artificial selection in grade 5 and 7 [16] and respectively 5, 7 and 8 [15]. Big numbers and time spans are difficult to grasp, especially for young students. Therefore many different representations and repeated inclusion should be made to consolidate this important aspect for evolution processes.

Another finding is the fragmented and missing concepts around reproduction and heredity. In the LPs these concepts are located at the bottom, because they are the cause for variation, different reproduction rates and therefore basis for population thinking. Linked with the time aspect, the thinking in generations is the foundation for population thinking. In both series [15, 16] most concepts about reproduction are tackled only once (mainly in grade 7) and remain isolated with respect to evolution. Only in grade 10 and 12, again very late, these concepts are dealt with in context of evolution. This is an aspect with high potential of improvement, because reproduction is a common everyday process for humans, pets, and plants with a lot of possible opportunities for experience for the students. Therefore these concepts could easily be integrated with artificial selection and therefore used for evolution education.

One further aspect is the topic of population related concepts. This concept is hard to grasp for students [9] and not widely included in Austrian biology textbooks [8]. Population concepts are not well represented in compulsory schooling grades in both series and not linked to evolutionary concepts. Also in both series in lower secondary texts use singular when writing about animals, therefore student thinking cannot be developed into the direction of population thinking or even previous students´ conceptions consolidate (e.g. typological thinking, where individuals are not recognised as individuals and all are the same, therefore build an entity, the species). This finding links to the previous findings [8] that natural selection has its effects at an individual level (see above) and therefore leaves out population and generation thinking. Another aspect is the mixture of the biological term population and the everyday use with respect to human population. Even the books mix both meanings and therefore cannot help learners to develop sound understanding about populations. Again, definitions and evolutionary context is only built up at the end of the school career.

Concluding remarks: the only topic which is widely represented in the textbooks is artificial selection, while sexual selection is found very scarce. It can be inferred from the results, that learning about evolution with the textbooks is only possible in aspects; at the moment the teacher has to compensate a lot for the learners. Whether this is possible and done in evolution education in the schools is left open. The method we applied was very informative about our focus evolution and with reference to our aim, to get systematic insight into textbook coherence. Other topics could as well be analysed with this approach, to get wider and deeper information about textbook coherence in complex biological topics.

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