



Students' Conceptions about Natural Selection – How Task Contexts Influence Evolution Assessment

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Abstract

There are few instruments for the assessment of students' conceptions about natural selection and biological adaptation so far (e.g. [1]). Existing instruments differ considerably in task format, features, contexts, etc. Studies in cognitive psychology, cognitive science, and science education have revealed that assessment item features like context associate with knowledge elicitation. Different tasks with varying contexts testing the same scientific concept may cue different student conceptions [2]. Little is known for whatever reason students activate either alternative or scientific conceptions about natural selection and biological adaptation in a particular task context. In the light of these results at least two conclusions can be drawn with regard to the construction of assessment tools: (1) the effect of task context on evolutionary explanations has to be better understood, (2) there is a clear need to control item features like context.

Our objective is the construction of an assessment instrument taking context as critical item feature into account. The study consists of three steps. (1) a cognitive linguistics approach to better comprehend students' context dependent explanations [2]. Within this framework two idealized cognitive models that describe the sense of the words "adaptation" and "selection" in everyday language have been developed [3]. The models were used to deduce predictions for students' application of alternative conceptions of selection and adaptation. (2) The predictions were tested in an explorative qualitative study with group discussions (12 groups, 3 students in each group, age 14 – 16). Four parallel sets of tasks about evolutionary phenomena were applied. Sets only differ in context. Data were analysed by qualitative content analysis [4]. Results of the explorative study will be integrated in the development of a quantitative assessment instrument (3).

Results of the qualitative study show a distinct influence of those task context features on students' explanations that were predicted by the cognitive analysis. For example, students express a large number of explanations within the conception of selection when confronted with a hint to variation. On the other hand, given the initial or final state of an evolutionary process (e.g. increased speed of extant cheetahs) students predominantly explain adaptation as a training effect and as an intentional process. In the latter case additional hints to variation have no effect on students' utterances. We suspect that the deep understanding of the structure of the semantics of adaptation/selection in everyday life can contribute to the investigation of contextualization patterns within evolutionary reasoning contexts and may add some benefits to the construction of assessment instruments. More results will be presented at the conference.

1. Introduction

Studies in cognitive psychology, cognitive science, and science education have revealed effects of task context on knowledge elicitation. Clough and Driver (1986) were the first to find that task context had a distinct influence on students' alternative conceptions about evolutionary processes [7]. Ha, Lee, and Cha (2006) described, that explanations about evolutionary processes employing mechanisms like "use/disuse" and "intentionality" were significantly greater in items using human or animal examples than in plant examples [10]. Kampourakis and Zogza (2008) were able to show that students gave different explanations for the same scientific concept (e.g. biological adaptation) within different tasks. They pointed out that the number of teleological explanations depended on the amount



of information given in the task context. More information resulted in a lesser number of teleological utterances [9]. In a recent study about students' explanations of evolutionary processes Nehm and Ha (2011) made considerable effort to control various context factors (trait gain vs. trait loss, taxon of the plant/animal in question, between/within species comparisons). They identified several contextualization patterns. For example presenting trait loss in task context led to a significantly greater number of alternative explanations than presenting trait gain. This pattern was found coherently in within and between species comparisons. With respect to existing assessment instruments Nehm and Ha conclude that *"explanatory failure appears in many cases not to be caused by the intrinsic absence of accurate knowledge, but rather its failure to be recruited, activated, or reasoned with in particular contexts"* ([1], 252/253). Weitzel & Gropengiesser (2009) tried to shed light on explanations for students' application of alternative conceptions about biological adaptation [2]. They analysed the semantic structure of the word "adaptation" in everyday language and compared that structure to students' utterances working on evolutionary tasks in teaching experiments. Adaptation in everyday language has a structure consisting of premises (e.g. necessity of a process of adaptation), peculiarities (e.g. reactivity, finality, gradualism, optimization) and an action from a source to a goal. This structure was found in the most common alternative student explanations of adaptation revealed in different studies. They concluded that the semantic structure of adaptation in everyday language might guide student utterances and therefore might function as a model from which predictions about students' explanations of evolutionary processes can be made.

2. Theoretical background

The study is framed by multiple and complementary theoretical underpinnings:

(1) constructivism (e.g. [8]), conceptual change theory (e.g. [8]) and experientialism (e.g. [3], [6]). Following experientialism thought is embodied, which means, that basic conceptions grow out of bodily experience within the physical and social environment. Bodily experience is made possible and restricted at the same time by the capabilities of body movement and the sensory system. Essential elements of our conceptual system are embodied by these experiences. They are called embodied conceptions. On the other hand there are plenty of conceptions which aren't directly accessible by bodily experience. We need to think in an imaginative way to explain them. Metaphors and analogies are tools that bridge between embodied and imaginative conceptions. With the help of a metaphor meaning can be conveyed to abstract areas, because a *„metaphor has a source domain, a target domain, and a source-to-target-mapping“* ([3], 276). In the case of adaptation, we can discern embodied conceptions (e.g. experiences with intentionality, mechanical experiences (adaptation of an object)), which are directly accessible, and imaginative conceptions (e.g. adaptation to social situations, better fitness as a result of physical activity).

3. Research questions and hypothesis

Our objective is the construction of an assessment instrument taking task context as a critical factor into account. In the first place, we ask, how different task contexts influence students' explanations. The following hypotheses were tested: Evolutionary tasks with

- (1) a hint to variation in task context elicit a greater number of explanations using selection as do tasks without that hint,
- (2) a hint to elements of the structure of adaptation in everyday language (initial or final state of an evolutionary process, perspective capacity) in task context elicit a greater number of alternative explanations as do tasks without that hint,
- (3) a hint to an organism that can be ascribed to some kind of perspective capacity (based on taxon) in task context elicit a greater number of alternative explanations as do tasks without that hint.

4. Research design and methodology



The study consists of three steps: Employing the theory of experientialism, we have developed two models representing the semantic structure of the words “adaptation“ and “selection“ in German language (1). Based on these models predictions are deduced for students' application of either alternative or more scientific conceptions of selection and adaptation depending on selected hints in task context ((a) hint to variation, (b) initial and/or final state of an evolutionary process, (c) organisms of different taxa). Predictions were tested in an explorative, qualitative study (2). Group discussions with twelve groups, each consisting of three students from the 8th and 9th grade from secondary schools were realized. Four parallel sets of tasks about evolutionary phenomena were developed. Each of the sets consisted of four tasks. Task context was standardized. Results of the explorative study will be integrated in the last step, (3) the development and evaluation of a quantitative assessment instrument.

5. Findings

Results of the qualitative study show a distinct influence of task context on students' explanations. According to the first hypothesis a hint to variation leads to a greater number of explanations taking variation into account. Students are more likely to pick up the concept of variation, and combine it with the concepts of different reproduction, survival success and gradualism. If no hint to variation is given, almost none of the explanations contain the concept of variation.

Hypothesis 2 is supported as well. Students predominantly explain adaptation as a final and intentional process. In that case an additional hint to variation has no effect on students' utterances. This applies regardless of the taxon of the organism in question (Hypothesis 3).

6. Discussion

As already stated in previous studies [9, 10] our study furnishes some evidence that task context affects students' explanations of evolutionary problems. One major problem for the construction of reliable assessment instruments regarding the subject of evolution is the lack of conceptual understanding of students' alternative conceptions. In our study we try to show that the theoretical framework of experientialism can provide insight into students' alternative explanations. Moreover results of the cognitive linguistic approach could be used to derive predictions about possible reasoning patterns depending on selected task context factors. Results of the explorative, qualitative study indicate that our approach might be helpful and will be tested in the upcoming quantitative study.

7. References

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