Abstract
In this paper we explore the idea that learning science involves mastering the language of school science and how it manifests in the classroom. This is done through an analysis of the intersection between conceptual aspects of biological evolution and social languages. Data was generated from peer group discussions among seventeen year old students in an upper secondary school. This data was used to address the question of in what ways does colloquial, inter- and school science language manifest and interconnect in the students’ discussion of the origin of biological variation. Students focus their talk on three notions: need, randomness, and development; while talking they move between colloquial- and school scientific language. Specifications are made step by step in negotiations, and the student groups make use of the notions more and more in line with school scientific language. We understand this to rely on the establishment of an arena where technical terms and scientific models may be introduced, negotiated, and made sense of, in particular in relation to personal and everyday experiences. In that way, this interlanguage discourse is an arena for learning.

Introduction
Learning science involves mastering the language of science, expressed by Lemke (1990) as learning to talk science and one aim of teaching in schools is to introduce the language of the scientific community (Mortimer & Scott, 2003). Language provides us with words, grammar, and semantics and it is, according to Brown and Ryoo (2008) the combination of conceptual and language components that enhance students’ conceptual understanding. One way of describing the intellectual task facing the students in school science fore fronting scientific language is the notion of learning demand (Leach & Scott, 1995, 2002). Learning demand constitutes this intellectual task in terms of mastering the school scientific language, and thus presupposes differences in social language (Bakhtin, 1981) between school science and everyday accounts of phenomena. In general the learning demand may be due to differences in the conceptual tools used, differences which relate to ontological assumptions and epistemological underpinnings of the knowledge used (Leach & Scott, 2003).

A prominent issue in science education research is students’ difficulties to master the school science curricula in practice. One important aspect is the competence of participating in conversations, whether they are part of scientific or everyday contexts, drawing on the body of scientific knowledge. In order to develop this competence, ‘explanations have to be ”talked into existence” for students’ (Ogborn, Kress, Martins & McGillicuddy, 1996, p. 14). The topic of biological evolution has a long history of touching on important parts of our worldviews, especially since it includes ideas on the origin of life in general and the origin of humans in particular. Biological evolution is at the same time a core part of biology as a school science subject (Millar & Osborne, 1998; Tidon & Lewontin, 2002), and is a good example of an area where there are numerous reports of students’ difficulties mastering the content (cf. Asterhan & Schwarz, 2007; Kampourakis & Zogza, in press). In this paper we focus students’ meaning making in relation to one core aspect of evolution, the origin of biological variation. The mere recognition of a variance in populations is reported to be an important factor in students’ meaning making (cf. Bishop & Anderson, 1990; Andersson & Wallin, 2006), and the reasons that students claim for the origin of the variation are diverse (cf. Banet & Ayoso, 2003; Southerland, Abrams, Cummins & Anzelmo, 2001).

Work in progress
The recognition of two spheres, mostly labelled *the everyday* and *the scientific*, is a point of concern for many studies in science education, emanating from several theoretical views. There seems to be consensus that the spheres could be identified and separated, for example in relation to social language, however what this implies for learning and teaching is a matter of discussion. Seeing everyday-scientific as a hard dichotomy, the focus could on the one hand depict the different spheres as incommensurable and regarding the everyday informal language as a source of creating barriers to learning, which has to be overcome, for example by a process of conceptual change (Anderson, 2007; Duit & Treagust, 2003). On the other hand, the focus could be on bridging the two accounts, not viewing them as an either-or issue and value the everyday informal language as an ‘asset that needs to be continually made use of in classrooms and in learning, but also to be studied and, explored and analysed in terms of its possibilities and its limitations’ (Varelas, Pappas, Kane & Arsenault, 2007, p. 67).

If the idea of different social languages is taken into consideration when teaching, it can enhance contextual shifting between everyday and scientific frameworks of understanding and appropriation of scientific language (Reveles & Brown, 2008) - with this the students could become bilingual. This ability to use, translate and distinguish between social languages is one of the aims of science education and the more confidently the students move between languages, the more mature is their understanding (Mortimer & Scott, 2003). When students work with making sense of the scientific language through the use of everyday language, they may engage using a new, personal, and dynamic language; an *interlanguage* (Barnett, 1992; Gomez, 2007). Lemke (1990) calls this mixing and bridging an ‘interlanguage, a sort of hybrid between colloquial and technical register’ (p. 173). This bridging of social languages has been taken into analytical use in science education research, for example when examining teaching and learning about biological adaptation (Ash, 2008) and when teaching and learning about evaporation, boiling and condensation (Varelas, Pappas & Rife, 2006).

This paper reports from a design-based research study where the teaching relied on an idea of the importance of students’ active engagement with the scientific content and language. An internal validation of the study as a whole was performed with a pre- and post test design; written questions were administrated just before teaching and the same questions a year later. In summary, the students’ answers about the origin of biological variation were significantly more in line with the learning goal of the intervention – the students’ written language became more scientific. At the pre test the students’ answers were relying on the terms need and intention (82 %), while a year later the students instead gave answers in terms of random changes (88 %). Apparently a change in language use on the level of words/terms has taken place, however it is another question whether this choice of words is established in a more general language use, and to what extent it is used in more informal contexts.

Taking the indication of what students learn as point of departure, our research aim turns to what the students do when engaging with the scientific language of biological evolution in the classroom; specifically exploring the students’ use of language when discussing in peer groups. Here we make analytical use of the theoretical tool of social language (scientific-, inter-, and colloquial language) and how these are constituted on the level of *words* (Brown & Ryoo, 2008) and the combination of words into *thematic patterns* (Lemke, 1990). Despite the merits of scientific words, for example, in adding conceptual depth and being productive as resource for understanding with more fine grained specificity, there is a risk that teaching becomes incomprehensible to many students if the scientific words are not connected to words used in colloquial language (Brown & Ryoo, 2008). Furthermore, in teaching we do
not want students to repeat the right words; instead the aim is that students express their understanding using ‘new’ formulations in a thematic pattern that is in line with the scientific meaning (Lemke, 1990) – ‘a [thematic] pattern of semantic relationships that describes the thematic content, the science content, of a particular area’ (p. 12). There is clearly a correspondence between the use of single words and thematic patterns, for example, in coherent explanations like the theory of evolution; ‘the systems of related meanings that constitute a scientific theory are learned and used primarily through language and correspond to a thematic pattern of thematic items (key terms, or ‘concept words’) and their semantic relations to one and another’ (p. 121)

**Making sense of biological evolution**

Learning demand can be viewed as a gap, the distance between everyday and scientific accounts of a phenomenon and consequently, greater distances will create greater learning demand (Leach & Scott, 2002). Students and school science accounts seem to be far apart when explaining the origins and continued existence of traits in populations, for example, students do not recognize the role of variation in this process (Bishop & Anderson, 1990). Furthermore, many studies have shown students’ frequent use of terms like ‘need, wish or intention’ as conceptual tools when explaining (cf. Banet & Ayoso, 2003; Kampourakis & Zogza, 2008; Zohar & Ginossar, 1998). The students’ prevalence for using need as explanation is explained by Southerland et al. (2001) as ‘need is a rationale for change’ originating in a phenomenological primitive (p-prim), a result of early experiences that are ‘internalised and become the vocabulary invoked to make sense of later experiences’ (p. 329). Keleman (1999) refers this to teleological-functional reasoning where every object has a purpose; a result of humans living in an environment with designed artefacts. On the whole, teleological reasoning is intuitive and fits well with colloquial views of development and evolution as a process of progress and improvement (Settlage, 1994), often towards a goal.

In addition to the role of variation as such, students have difficulties to see the role of randomness in the process of shaping variation (Bizzo, 1994, Klymkowsky & Garvin-Doxas, 2008). This is not a problem according to Morechá (2004), who do not see any need for the notion of randomness when teaching evolution, not initially anyway. It would be enough to assume that heritable variation occurs, like Darwin did; by that the theory would be less provocative to students with a creationist background. However, if the explanation is grounded in neo-Darwinian theory the ultimate origin of variation (mutation and recombination) is important to recognise. It is an empirical question whether the explanation of the origin of variation could wait until after the introduction of the concept of selection, which Geraedts and Boersma (2006) suggests. A few intervention studies show effective learning, and the use of peer group discussions seems to be supporting, especially if the discussion includes dialectical argumentation (Asterhan & Schwarz, 2007) or different explanatory models (Jimenez- Aleixandre, 1992; Passmore & Stewart, 2002; Wallin, 2004)

As seen above, students’ use of words such as ‘need’ is often portrayed as a pointer towards reasoning in line with teleological explanations, thus being a hinder to further learning. On the other hand, anthropomorphisms and teleological expressions (such as need) have heuristic, emancipatory, and pedagogical value for learners, as shown from studies concerning learning science in general (Brown & Ryoo, 2008; Gomez, 2007; Varelas et al. 2006) and specifically when learning biological evolution (Ash, 2008; Kattman, 2008, Zohar & Ginossar, 1998).
Renderings of everyday and scientific spheres in science education research

When discussing the two spheres, mostly labelled the everyday and the scientific, certain characteristics are commonly used to describe and differentiate the two. The everyday sphere is often described with words like ‘improvisation, ambiguity, informality, engagement, and subjectivity’ while the scientific side is described with ‘rationality, precision, formality, detachment, and objectivity’ (Warren, Ballanger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001, p. 530). On the other hand, what the existence of these spheres implies to learning and teaching is a dividing line between research approaches (Anderson, 2007), for example the spheres could be regarded as complementary (Vygotsky, 1986), dichotomous (Chi, 2005; Shtulman, 2006), or continuous (Brown & Ryoo, 2008; Warren et al. 2001).

In the discussion that refers to everyday and scientific concepts one standpoint is that the spheres are complementary. This is what Vygotsky (1986, p. 158) argues when stating ‘the strong side of one indicates the weak side of the other, and vice versa’; what differs is the origin and the aim of the concepts. In respect to origin and aim Vygotsky often refers the everyday concepts as spontaneous since they arise from everyday experiences and are formed in a process not aimed at mastering the concepts. The opposite counts for the scientific concepts; they are introduced in formal settings (often school) where the aim is to master the concepts. Introduction of both types of concepts follow the process of internalisation; both appears first on the social level (between people) and then, after personal sense-making, transformed to the individual level. Noteworthy is that Vygotsky’s framework includes all sciences (not exclusively natural sciences), and he often use of the notion formal concepts and knowledge (Vygotsky, 1978).

The variety in labelling everyday concepts or knowledge are evident when looking at the 8400 entries in Reinders Duit’s (2009) bibliography Students’ and Teachers’ Conceptions and Science Education (STSCE). These conceptions are, according to Roth (2008) labelled as: mis-, pre instructional-, informal-, naïve-, non standard-, canonical-, or alternative conceptions. Labels like these points towards a dichotomy between the everyday and the scientific accounts, often with the assumption that students’ everyday experiences result in misconceptions (cf. Chi, 2005) or naïve theories (cf. Shtulman, 2006). In studies that draw on the conceptual change model the everyday concepts are seen as barriers to further learning; consequently the starting point when designing teaching for conceptual change (Duit & Treagust, 2003) is to regard students’ everyday knowledge as an alternative knowledge that has to be changed or exchanged. In contrast, Scott, Asoko & Leach (2007) suggest that it is school science that offers students an alternative way of explaining natural phenomena.

Instead of viewing everyday views as incompatible with scientific views and, thus, in need of replacement, the everyday language could be seen as an asset and resource when learning the scientific language (Varelas et al. 2007, Warren et al, 2001). This guided Brown and Ryoo (2008) when making an intervention study in grade 5 among minority students about photosynthesis. They firstly establish conceptual understanding of the terms in everyday language; only after that the scientific terms are introduced as alternative. For example they encourage and allow the use of expression like ‘plant food’ (not glucose), ‘energy pouch’ (not chloroplast), ‘light’ (not photon) and ‘the air that humans breathe out’ (not carbon dioxide). A control group was from the beginning introduced to the scientific terms, but the experimental group performed significantly better as estimated with a pre- and post-test design. The outcome is explained by Brown and Ryoo by the ‘content-first’ strategy; first teaching scientific concepts in everyday language and then provide instructional scaffolds into scientific language. The teaching approach built a conceptual continuity between students’

Work in progress 4
everyday and scientific communication, which eased the minority students’ feelings of anxiety and cultural conflict.

The notion of interlanguage or hybrid language is often used in the knowledge domain of foreign language learning. However, if we take the standpoint that learning science involves learning to talk science; the idea of an interlanguage is useful in analysing the mastering of the language of school science. A core point, according to Warren et al (2001), is allowing everyday reasoning to become an intellectual resource in sense-making. True recognition of both languages is shown by Gomez (2007) when students made use of multiple discourses when doing a science fair presentation. The interplay between everyday and scientific resources enhanced students’ science understanding. Another way of expressing the hybrid mode of communication is coined ‘double talk’ by Brown and Spang (2008). Both teacher and students used vernacular and scientific language when performing a task about classification of organisms. Ash (2008) focus the interplay between everyday and scientific discourses when analysing a successful learning episode about biological adaptation. The outcome, students ability to talk and reason like scientists, is attributed to a switch back and forth between scientific and everyday discourses. This is in line with the advice from Lemke (1990) to let ‘students translate back and forth between scientific and colloquial statements and questions’ (p. 172). Students, seen as a group, will start with their colloquial language and along the way their version of scientific language will be an interlanguage.

**Specific aim and research questions**

The different ways of viewing the relation between the everyday and scientific spheres implies different research focus. When viewing the relation as a dichotomy the accounts are mainly understood in terms of conceptual understanding; depicted as altered status of different explanatory models or change/exchange of individuals’ ideas (Anderson, 2007). The complementary and continuous views connect individuals’ conceptual understanding with language use, which theoretically relies on the idea from Vygotsky (1978) that in the child’s development and learning there is a passage from social contexts to personal understanding. It means that we first encounter, to us, new ideas in a social context, these encounters provide the tools for the process of internalisation, a kind of individual sense making.

A strategy to empirically seize what is involved when students make sense of biological evolution would include examination of instances in the classroom where meaning of words and thematic patterns are negotiated orally. Furthermore, if the ambition is to explore ways that students bridge between the colloquial and scientific languages (Varelas et al. 2007) we have to seek moments in the classroom discourse where colloquial language is likely to be expressed. One interesting candidate for such moments are peer group discussions that are an arena for negotiations in a more informal and colloquial language (Southerland, Kittleson, Settlage & Lanier 2005; Jimenez-Aleixandre, 1992).

This paper thus aims at exploring what happens in peer group discussions where students discuss the origin of biological variation; what will the students focus their talk on? The research focus is on students’ language use, constituted as the words and the thematic patterns that the students choose to engage in. This means an analysis of the intersection between conceptual aspects of biological evolution and social languages. Specifically, this means addressing the question of in what ways does colloquial, inter- and school science language manifest and interconnect in the students’ discussion of variation in biological evolution.
Methodology

Sample, context and data collection

The data was generated within a collaborative project where researchers and teachers explore and design teaching-learning sequences (Andersson, Bach, Hagman, Olander & Wallin, 2005). The project was enacted in a Swedish upper secondary school and included one teacher and 48 students from two school classes attending the natural science program. This program is the only with a substantial amount of science-related topics and is considered to be a demanding choice. The actual school is a public school situated in a middleclass suburb with some rural features; it is the only secondary school in the municipal and the school offers all the national study programmes and attracts most of the students in the vicinity. The students were at the time seventeen years old and it was their second year at the school but their first course in biology. The teacher taught both groups in this study, had formal qualification in teaching biology, and extensive experience as a teacher.

The project was the first cycle in a design-based research project and was rather tentative both when it comes to research design and teaching design. A didactic analysis of the syllabuses resulted in a formulation of a learning goal, which broadly was phrased as: the students should be able to use the theory of evolution as a tool when explaining evolution of life on earth. The motto “theory as a tool” was supposed to imply that the theory should be used as theoretical leverage in the students’ meaning making of biological evolution. Besides identifying the learning goal, an identification of the nature of students’ everyday articulation of biological evolution was made; this analysis emanated mainly from literature review of science education research. Three issues that many students had difficulties with were identified: the role of variation within populations, selection as differential reproductive rates and that students often use terms like “need, wish, or pursue”, as conceptual tools when explaining biological change.

The students were given diagnostic questions about a week before the beginning of the teaching and these questions were also given the students a year later as a delayed post test. Other documentation from the sequence included student log book entries and some videotaped peer group discussions. The lesson that provides us with the main data used for the analysis in this paper was a practical organised around three activities: an examination of fossils, an exploration of the evolution of humans, and a small group discussion about the origin of variation. Both the format of the practical and the use of small group discussions were rather well known to the students. The group discussion that is focussed in this paper was held during the third lesson of the sequence that was totally eight lessons long (each lasting 90 minutes). The two introductory lessons, mainly orchestrated by the teacher, concerned fundamental genetics, including heredity, cell division, mutation and the idea of a common descent of life on earth.

In this practical, the students formed three groups, which were divided by the teacher into 12 small groups moving from one activity to another in the order that was most convenient. In all, 29 students in 7 of these small groups gave permission to be video taped, most of them having 4 members. When performing the discussion they went to an adjacent room, started a video camera, discussed, turned off the camera and continued to the next activity. The remaining 19 students in 5 groups had their discussion in another room. The students were informed that the teacher would not see the tape until the course was ended and the grading finished.
The multiple choice task that the students’ discussed was introduced by the teacher thus: ‘Comment the alternatives one by one and argue against and for. Then if you are able, come to a mutual agreement. We will follow up the discussion in the next whole class lesson’. The task to discuss was formulated as:

‘Throughout the course of evolution living organisms have developed a lot of different traits. What is the origin of this enormous variation?
- The traits arose when they where needed
- Random changes in the gene pool of the organisms
- Living organisms pursue development
- Great variation is needed in order to get balance in nature’

The students’ discussion is structured and framed by the formulation of the task. The wording presupposes that evolution has taken place and that there is a variation in traits. The alternatives in the multiple-choice question were supposed to illustrate common ideas about the origin of variation. The alternatives are in this way a reflection of the teacher’s initial view of the conceptual aspects of the learning demand.

Analytic procedure
The analysis principally included three steps:
- Quantitative and qualitative descriptions of what notions/words were important in the students’ discussion.
- Looking at the meaning and sense (Vygotsky, 1986) of the most frequent notions in the students’ discussion – need, randomness, and development – and dividing the students’ talk into sequences that each could be attributed to being described as colloquial, inter-, or school science language.
- Looking at the interconnections between different social languages in longer parts of the text.

The analysis commenced with making ourselves thoroughly familiar with the empirical data, through, for example, watching the videotapes repeatedly, identifying interesting episodes and in the process moving our teacher instincts to the back. At the same time, the students’ discussion was transcribed, which included comments about important pointing, gestures and pauses. Transcripts from the groups’ discussion were first analysed as a whole, meaning that all talk from seven groups (ranging between 6 and 19 minutes with an average of 11 minutes) were divided in sequences where different conceptual notions were discussed, no matter if they originated in colloquial or scientific language. In table 1 this is summarised as percentage of the groups total talking time; for example, development occupied 19 % (105 out of totally 540 seconds talk) of group 7 while group 6 spent 40 % (460 of totally 1140 seconds) of their talking time on this issue.

<table>
<thead>
<tr>
<th>Group</th>
<th>Members</th>
<th>Time (minutes)</th>
<th>Need/randomness (%)</th>
<th>Development (%)</th>
<th>Other (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>19,5</td>
<td>43</td>
<td>36</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>19</td>
<td>47</td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>15</td>
<td>45</td>
<td>31</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>6</td>
<td>64</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>6</td>
<td>62</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>19</td>
<td>38</td>
<td>40</td>
<td>22</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>9</td>
<td>51</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>Average</td>
<td>4</td>
<td>11</td>
<td>50</td>
<td>27</td>
<td>23</td>
</tr>
</tbody>
</table>

Work in progress
Table 1 shows that half of the time are the topic in the discussions need and/or randomness; mainly these two are discussed at the same time and in contrast to each other (about one third of the total time). Development is the topic in a quarter of the time and in the remaining quarter ‘other’ issues are in focus. This other is one third of each: off task (playing or talking about politics), preparations (mainly reading the question) and on task but not about need, randomness or development (for example: twins, HIV, human length over time, traits in the future, circumcision, animals/humans etc.).

After concluding this first step in the analysis, we went into attempting to understand the ways in which the students gave sense to and expressed the meaning of the three central notions: need, randomness, and development. This analysis took as a starting point the distinction between meaning and sense by Vygotsky (1986): meaning is the stable, generalised, collective and lexical zone of a word; which in this analysis is close to the scientific language (the way the notions were supposed to be understood as); sense is the situated, personal, local and creative part, depending on the context of the talk; which is how the students interpret and reformulate the notions in their talk. By describing the sense given to three notions in the students’ conversation, and comparing it to the meaning of the notions, we attributed sequences of the conversation to belonging to three types of social languages; colloquial, school scientific, and inter-language. Our hypothesis was thus that these pre-defined social languages could be empirically discerned and distinguished. These initial definitions of the three social languages was based on a synthesis of literature on everyday and scientific language (principally Lemke, 1990; Warren et al. 2001; Wellington & Osborne, 2001), discourse and interlanguage (principally Ash, 2008; Brown & Spang, 2008; Gomez, 2007), and everyday/spontaneous/colloquial and scientific concepts (principally Roth, 2008; Vygotsky, 1978; Warren et al. 2001). We made an explicit definition for us to use as analytical guide in this work:

Colloquial language is open, allows the discussion of most topics, as well as different ways of reasoning side by side. Arguments can be based on person and personal experiences. There is room for true recognition of values and emotions. A consequence of this openness is that great specificity in what is said is not required. The colloquial language is oriented towards oral discussions and is informal in nature.

Interlanguage is characterised by bringing together elements of scientific considerations with personal experiences. It involves translations between languages that open an arena where talk is more freely constituted, for example not specifically adherent to the standards of scientific communication.

School science language is characterised by restrictions on what is discussed and the ways in which it is discussed. It displays specificity of how notions are used and it is productive in expressing complex causal relationships. Argumentation is based on models or general ideas rather than personal experiences. The school science language is oriented towards written text production and displays a degree of formality, also when used in oral discussions.

In this way, students’ utterances (often one ‘sentence’ or claim) about need, randomness, and development were linked to the three languages. This second step in the analysis, builds from the level of analysing words towards analysing thematic patterns. The foundation and starting point of the analysis are ‘notions’ but the notions are embedded in utterances that may be rather diluted thematic patterns. On the other hand these utterances are made within all three
languages, and as such they contribute to researchers/teachers understanding of the students’ sense-making of the notions.

In order to discern how thematic patterns were articulated within different languages, which was our third step in the analysis, it was necessary to go back to the whole data set, and specifically look for sequences in the discussions where the use of language fluctuated. One reason for choosing this specific peer group discussion was that the question the students discussed where a product of a didactical analysis of both the scientific and colloquial accounts of the origin of biological variation. The insights from this analysis of the learning demand were seeded into a multiple questions, where the alternatives were supposed to reflect different views of the origin of biological variation. The assumption was that the students’ discussion would externalise the students’ articulation of the learning demand. This would be a more dynamic version of the notion of learning demand in all three dimensions, conceptual, epistemological, and ontological. The primary result of the first step is presented above, in Table 1, while the results of the second and third step are presented in the Results section under separate headings.

Results
The analysis of the empirical material, using the three social languages as categories, has resulted in a contextualised description of the three languages, valid across the three prominent conceptual notions need, randomness, and development. Using different kinds of language in the discussion, students negotiate the meaning of these notions and the context in which they should be understood, and contrast them to what they are not. These results are presented in three subsections below. First, the contextualised description of the three languages is presented as a summary of our results. Second, the categorisation is exemplified for the three notions separately. Third, an exploration of how the different languages and notions are linked and integrated in the discussion is presented with two examples from two peer groups.

Three conceptual notions expressed in three social languages -- a summary
In relation to the three pre-defined kinds of languages (colloquial, inter-, and school scientific) several mutual characteristics of students’ sense-making emerged.

In colloquial language, students mainly rely on an unspecific interpretation of the notion, often the most generally applicable. Explanations have strong flavours of intentionality; this could be explicitly articulated as for example ‘planned mutation’. However, most frequent are reasoning with teleological logic, for example ‘need in order to survive’ or ‘developed accordingly to environment’. Often value words reinforce intentionality, for example development has a direction, for the better. The standing of the notions and events are often seen as natural and given a taken for granted domain of applicability; thus there is no need for explaining events.

Interlanguage opens up for negotiations and delimitations of what the notion is and is not, for example that randomness is not the only process that explains development of traits. Furthermore students explicitly argue that the individual’s need and strive for development is not necessary in explaining traits. Technical terms are used, however sometimes in a tentative and mimicking style. When value words, like good/bad/right are used, they are not contextualised with clarifications, for example, what constitutes a good or bad trait in a specific environment.
In school scientific language students specify the meaning of notions and mainly link examples to general models or theories. This is done in congruence with theory or model, for example need is seen a result of selection and refers to ‘group’, not individuals. Random changes plus environment may lead to selection. Furthermore, the difference (and the importance of that difference) between somatic and sex cells are articulated. Development is seen as a two-step process, starting with an existing variation and then selection. Value words are appropriately contextualised, for example ‘better trait’ is delimited to mean resistance of penicillin in an environment with penicillin.

**Empirical exemplification for the three notions**

Tables 2 - 4 contain examples from students’ talk in their sense-making process. Each kind of language is exemplified for each notion with two examples of students’ talk. Need and development were more frequently used in the colloquial language than in school scientific language (in interlanguage somewhere in between). The opposite applied to the frequency distribution of the notion of randomness, as well as to more technical terms such as mutation and sex cells. Discussions using the notions of need and development seem to evoke less use of technical terms.

### Table 2. Examples of students' talk about the conceptual notion of need.

<table>
<thead>
<tr>
<th>Colloquial language</th>
<th>Interlanguage</th>
<th>School scientific language</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Because it isn’t necessary, they don’t need it in order to survive (Group 3, line 99)</td>
<td>- If everything was great and they had all the traits needed in order to survive in an environment, they hadn’t changed to the worse, they change to the better (Group 7, line 5)</td>
<td>- Not originated because it was needed, but remained when it was needed in that case (Group 1, line 31)</td>
</tr>
<tr>
<td>- Those that are in Africa are black, in order to protect them against the sun (Group 6, line 15)</td>
<td>- The specie can not have a conference … saying now we are bound to have (Group 4, line 17)</td>
<td>- They [the traits] originates by randomness but those who survive are those that are needed (Group 6, line 39)</td>
</tr>
</tbody>
</table>

### Table 3. Examples of students’ talk about the conceptual notion of randomness.

<table>
<thead>
<tr>
<th>Colloquial language</th>
<th>Interlanguage</th>
<th>School scientific language</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Yes, but no such mutation that is totally wrong, but one that is planned or a bit thought-out (Group 7, line 11)</td>
<td>- But it can not be only some who gets the right changes. For example monkeys, they can’t just get random; like that they will become good at climbing (Group 5, line 06)</td>
<td>- There were always mutations and all the time it were those who had that mutation that survived and carried it on (Group 1, line 31)</td>
</tr>
<tr>
<td>- It has occurred random changes /.../ and new traits arise, it is obvious that new traits arise (Group 1, line 71)</td>
<td>- Those mutations that are like good they have lived on but those who were bad have like died out (Group 2, line 20)</td>
<td>- When mutations occur it is not the changes in the body that matter, in relation to the offspring, what matters is what happens in the sex cells (Group 3, line 51)</td>
</tr>
</tbody>
</table>
**Table 4.** Examples of students’ talk about the conceptual notion of development.

<table>
<thead>
<tr>
<th>Colloquial language</th>
<th>Interlanguage</th>
<th>School scientific language</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Because you want to develop, you always strive to develop (Group 7, line 4)</td>
<td>- No not like ... now I will develop; now I will have webbed foot (Group 1, line 51)</td>
<td>- I want to believe that they developed it themselves, but they can’t just do it /.../ if you should say, what the hell I like to be really damned good-looking and beefy and hell … you can’t influence it yourself (Group 3, line 59/61)</td>
</tr>
<tr>
<td>- It is not a mutation it is development … mutation isn’t that a sudden change? /.../ development is when it happens slowly (Group 2, line 26/28)</td>
<td>- Everyone develops in different directions all the time and those who are best survive (Group 4, line 26)</td>
<td>- All those who had a certain trait managed better in one part of the lake, and then they developed there (Group 5, line 17)</td>
</tr>
</tbody>
</table>

*Use of multiple languages in the students’ discussions*

In the sequence shown in Table 5, the discussion is oscillating between different languages, thus making different interpretations of the notion *randomness* visible.

<table>
<thead>
<tr>
<th>Table 5. Excerpt from group discussion.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dee</td>
</tr>
<tr>
<td>the specie can not have a conference ... saying now we are bound to have</td>
</tr>
<tr>
<td>... random changes happens</td>
</tr>
<tr>
<td>but they are not totally random ... after all there is a sort of underlying thought</td>
</tr>
<tr>
<td>Diana</td>
</tr>
<tr>
<td>or not exactly thought but .. of course random changes happens .. but the changes that survive are the good ones</td>
</tr>
<tr>
<td>Dee</td>
</tr>
<tr>
<td>if it among the cheetahs were someone who could run faster and someone slower then ... those who where big and strong they got much food and then more and more of these came about</td>
</tr>
</tbody>
</table>

The sequence starts with interplay between languages, first with claiming that intention is not the agent when it comes to changes within species (expressed with colloquial pointers like *conference* and *are bound to*); Dee seems to embrace the scientific idea that random changes do occur. However, this is followed by a passage of delimitation and restriction when Dee invites to a renegotiation on whether changes are *totally random*. This is picked up by Diana with an explicit remark pointing at intentionality. Dee’s answer to this is again interplay between languages. The school scientific language when stating: *of course random changes happens* and the colloquial language when labelling a change as ‘good’. The distinction between good and bad has to be explained in a school scientific language. First of all good, or bad is only readable afterwards, thus her explanation becomes teleological. Furthermore, there is a normative undertone in good/bad that is hard to judge without context. However, in the latter part of Dee’s utterance she turns to a reasoning that is more in line with school science language. She changes to causal explanation; if there is an existing variation (cause) in the population then some variants would become more frequent.

**Work in progress** 11
(effect) than others. Her reasoning about selection (although without mentioning the technical term) points, implicitly, at differences in survival and reproduction rates. On the surface, this example could be seen as a fluctuating monologue of Dee with mainly interlanguage components. However, the brief remark from Diana, with colloquial flavour, serves as leverage for Dee’s articulation. The expression, underlying thought, seems to trigger a clarification of the extent to which intention could be an applicable explanation. Thus the colloquial language functions as an intellectual and discursive resource when specifying the school scientific account of the notion randomness.

**Clarifying the meaning by contrasting need and randomness**

The next example is from the very beginning of a discussion where a group contrasts the notions need and randomness as different explanations of the origin of traits. The sequence starts with Ewan’s reminder of what the teacher earlier had talked about². Ewan tries to make sense of the example with cichlid by rephrasing the teacher’s words into his own colloquial language; thus he exemplifies a kind of interlanguage. However, his conclusion about development (they must have developed accordingly) is formulated close to colloquial language since it has a flavour of intentionality.

**Ewan:** those cichlids that he talked about, they who jumped to another lake where it was totally different conditions .. consequently they must have developed accordingly

Erik: well ... the changes are random but those who have the right changes survive

Emil: exactly

**Erik:** it depends on what you mean with the question

The first part of Erik’s answer is more in line with school science language as he states that the changes are random. He then connects change to survival with the value word right (changes) specifying that the word right is judged according to survival. However, there is no exemplification in the dialogue and Erik expresses doubts about how to interpret the formulation of the task.

**Emil:** well ... it can’t be just random changes either

When Elias enters the conversation the use of the word right is contested in connection to randomness. Elias point is that it is unbelievable that random chance could be the origin of the accumulation of changes that enhance the trait of climbing among monkeys. Elias’ conclusion is reinforced by Emil’s interlanguage remark that random changes are not the only possible explanation of the origin of variation.

**Elias:** but it can not be only some who gets the right changes. For example monkeys, they can’t just get random; like that they will become good at climbing

**Emil:** well ... it can’t be just random changes either

These two comments look at first sight rather alike but point at two different referents. Erik refers to selection starting out with an awareness of existing variation (those who were useless) and its consequence, thus he uses school scientific language. Emil refers to traits with a commonly coupled phrasing ‘bad/die and strong/survive’. This could be scientifically sound but is not exemplified; thus it is an example of interlanguage. The phrasing of Emil could be due to the colloquial Swedish translation of the expression ‘survival of the fittest’. In Swedish this becomes ‘survival of the strongest’ and Emil don’t make any specification of the meaning of strong in this case.

**Ewan:** wasn’t it the DNA-chain that changed ... those long
Manuscript

Emil: yes, some parts can change and you get better traits
Ewan: when you say random
Ewan: quite ... random, not accordingly to need

Here Ewan puts his view of change on the table, with a specification of location and by using a technical term (DNA-chain). Emil connects change with trait and Ewan follow up and connect both these two with randomness. Ewan’s last remark explicitly articulates the contrast between randomness and need.

Erik: no
Emil: but if it is just random changes in the DNA-chain and the traits ... then should people, or these cichlids that didn’t have good traits, become extinct very quickly because they changed so much
Erik: all those who had a certain trait managed better in one part of the lake and then they developed there

Thematically, Emil continues to reason in terms of ‘black and white’; changes are either good or bad, and having bad ones lead to extinction. Erik’s last contribution specifies the reasoning into a more school scientific language, through connecting a certain trait with the environment. There exists a variation (some had a certain trait), and the variation is not neutral when meeting the environment (managed better in one part of the lake). The variation leads to selection; and selection here is equalised with development.

Emil: but then it has gone very fast
Ewan: so they didn’t develop according to need then
Erik: sort of ... it depends on how you look at it; if you see it as a whole specie it is possible
Ewan: ... yes ... next question

The discussion has earlier delimitated and specified the context where randomness has potential as explanation, and now Erik suggest that the notion of need might be applicable to species. Once again Ewan has to verify in plain language that need is not a reason for development, and this ends this section of the talk and they proceed with the next issue.

In summary, this group is engaged in the sense-making of a teacher introduced example and they co-construct an interpretation that is in line with school science language. In other words they use the opportunity they are offered (to discuss) as an arena for learning. One example is the negotiations of how to understand the notion of development, which is first expressed by Ewan as those cichlids that he talked about, they who jumped to another lake where it was totally different conditions .. consequently they must have developed accordingly, which is development expressed in colloquial language. The talk goes on with delimitations in interlanguage, for example development is viewed in the light of being good or bad. Then Eric connects variation and good/bad to environment all those who had a certain trait managed better in one part of the lake and then they developed there, thus an expression in line with school scientific language.

In addition, what makes this a productive talk is that the notions need and randomness are contrasted, as explanation of development. First the discussion delimited and specified the context where random had potential as explanation. Context is here interpreted as ‘level of organization’, which is an important construct in biology. If the levels are labelled: molecule – cell – organism – population – specie – community; the group placed the origin of random change on the level of molecules (DNA). As for the notion of need, the group agreed that is not an agent on the level of organisms (individuals) but perhaps on the level of species.
Discussion and conclusion
The students chose to focus their discussion on three conceptual notions; that need and randomness are prominent notions are perhaps not surprising taken that the multiple choice question the students discussed were seeded with insights from an initial analysis of the learning demand. Despite the rich literature context about these notions we do argue that our analysis provides new insights of how students make meaning of these notions, especially in the light of social languages. However, first we want to pay attention to students’ prevalence of discussing the notion of development, which is an observation that is relatively less touched upon in research literature.

We assume two reasons for students’ willingness to negotiate their understanding of the notion of development, where one is inherent to the Swedish language because in colloquial Swedish language the word development replaces evolution more or less like a word parallel. However there are several connotations of the word development, which may have different merits when used scientifically. For example it could mean that somebody develops an idea or a habit, an engine develops heat and children develop to adults. The other reason is that the word development (and also evolution) often is conceived as development towards something, for example better conditions. This influence, of anthropomorphic and intentional reasoning, is seen in our results when students in colloquial language say: because you want to develop, you always strive to develop (group 7, line 4). What this implies in a scientific context is a matter of negotiations in the students’ talk.

The presence of the colloquial language is not problematic in itself. On the contrary, what we have observed is that over time in the students’ discussion, the scientific quality of their explanations is improved; see for example the negation mentioned above about how to understand development. The differences between the three notions are discursive delimitations; it is a matter of specifications of meaning of the three notions. For example, specifications are made step by step in negotiations, and the student groups interpret the notions more and more in line with school scientific language. We understand this to rely on the establishment of an arena where technical terms and scientific models may be introduced, negotiated, and made sense of, in particular in relation to personal and everyday experiences. In that way, this interlanguage discourse is an arena for learning. On this arena for learning, elements of colloquial origin and school science origin are brought in contact with each other, and the meaning of terms and notions can be explored, detailed, and negotiated.

The notions of randomness and need are used as opposites when students explain the origin of variation. Both notions are productive, and the more colloquial notion – need – is an intellectual resource when explaining the origin of variation. Without delimitations and negotiations of the notion of need, the school scientific explanation would have been less nuanced and accurate. We argue that colloquial expressions such as ‘need in order to’ triggers refinements in line with scientific language such as, not originated because it was needed, but remained when it was needed in that case (group 1, line 31). The actual process of constructing explanations could be described as learning; anyhow it is hard to separate articulation from learning since they ‘go hand in hand, in a mutually reinforcing feedback loop’ (Sawyer, 2002, p.12). In our view knowledge has to be negotiated and exemplified not seen as static and self-evident. In our study these negotiations and exemplifications are a core part in what constitutes students learning; thus it is important to explore students’ talk. Possibly we explore ‘learning as it take place’ (Ingerman, Linder & Marshall, 2009; Wickman & Östman, 2002).
This study also exemplifies that students identify the type of social language in which notions are expressed, and this identification trigger the route of conversation. That students themselves identify differences between social discourses is also concluded by Ash (2008), and she argues that the meeting of everyday language and content aspects was foundational to this process. Furberg and Ludvigsen (2008) also noticed that students make use of both their everyday and scientific knowledge when exploring students’ meaning-making in socioscientific issues. In our study this is exemplified when, for example, the notion is expressed with a colloquial language, the discussion that follows this identification of social language, clarifies and specifies the meaning of the notion in a school scientific language.

The task presented to the students had the origin of variation as the intended object of learning. However, when the task was enacted in the students’ discussion, the object of learning, without controversy immediately expanded to evolution as a whole. This points, firstly, to that it is, as a teacher, important to be aware of this kind of re-interpretation on the side of the students, and secondly, that listening to what the students are saying is paramount in grasping possibilities for productive learning action on the side of the teacher. Such listening may be supported by the descriptions of social languages and use of conceptual notions that we have provided. This calls for further research on teachers scaffolding in terms of language use, suggestively in line with what Brown and Spang (2008) describe as ‘double talk’ and Gomez (2007) ‘bridging talk’. These expressions, double and bridging, refer to both the awareness of different languages, and to the competence in combining languages. An increasing competence in combining the everyday and scientific languages, without reducing the value of either side, would be a contribution when teachers perform assessment for learning (Black, Harrison, Lee, Marshall, & Wiliam, 2003).

The learning demand of the origin of variation thus encompasses both language and conceptual aspects: need, randomness, and development are important meaningful notions in reasoning and students develop their use. The notions get a scientific meaning in spite of their colloquial origin and students have to enter the arena of interlanguage in order to connect colloquial and school scientific reasoning; then they understand more about the notions as such. Furthermore, students understand how colloquial and school scientific language differs, and could be kept together when discussing biological evolution. The latter relates to a more general learning demand, that is mastering the social languages. We have seen that language and conceptual aspects interact in intricate ways, and that the theoretical descriptions of colloquial, inter-, and school science language are meaningful and productive when making sense of students’ discussion on the origin of variation. We thus infer that similar empirical investigations on different topics are of interest both to the fields of research and practice in science education.

Notes:
1 In the task, the evolvement of traits is written as development of traits. This reflects that there is no colloquial verb corresponding to evolve in Swedish. Thus the more general term of development is used.
2 The example was about distantly related cichlids in Lakes Tanganyika and Malawi which had evolved, and become alike by occupying similar ecological niches. (Stiassny & Meyer, 1999).

Bibliography


Work in progress


