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Interest and emotions in science education

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Abstract: Interest is an important affective variable that has been found to be associated with focused attention, higher cognitive functioning, and learning, which makes it an important variable for learning in science. In research on interest and learning this interplay is almost always seen in a unidirectional way where interest is a facilitator for learning. The aim of this chapter is to challenge this unidirectional view in on the role of interest – with special emphasis on feelings - in learning science. We do that by reversing the direction and investigate if learning science can be a facilitator for developing interest. We start with a theoretical outline of interest and feelings connected to this. This will be put in to a context of students' work in upper secondary biology education for an empirical approach to this interplay. The empirical work will provide arguments for the theoretical outline but also qualify the final discussion on the role of interest and the attached emotions, feelings and moods in science education in general on theoretical and practical level and the correspondence with leaning science.

Keywords: interest development, learning, affect,

1. Introduction

Over the last four decades, a great deal of educational and psychological research was devoted to the clarification of the cognitive processes involved in students' learning in science. Although these efforts have come a long way to explain the unique nature of student learning, they also demonstrated how little is

known about the influence of affective variables (Pekrun, 2006). Affective variables, such as enjoyment, are central for learning, because they guide cognition, assist peoples to select among beliefs, arrange priorities among goals, determine access to memories, and provide heuristics that influence reasoning, judgment, and planning (Oatley 2001).

In this chapter, we take a psychological perspective on emotions and interest in science education. We begin by exploring topic and epistemic emotions that is emotions triggered by the characteristics of the learning content as well as triggered by the engagement with that content. Then we unfold the concept of interest and link it to emotions and learning.

Affective variables are central to emotions and are physiologically bound to subsystems of the limbic system (or paleomammalian brain) (Pekrun 2006). Emotions are defined as multi-component, coordinated processes of psychological subsystems including affective, cognitive, motivational, expressive, and peripheral physiological processes. The term emotion refers to a collection of responses triggered from parts of the brain to the body, and from parts of the brain to other parts of the brain, using both neural and humoral routes. The end result of the collection of such responses is an *emotional state* (Damasio 1998).
Such emotional stage is individual and can be caused be prior experiences. For instance Arne Öhman, Anders Flykt, and Fransisco Esteves (2001) found that people afraid of spiders and snakes had higher attention towards pictures where some contained their specific object of fear. So just seeing a picture of a spider or a snake could cause the emotional state of increased attention.

Students experience different emotions during science lessons in school. These emotions can be positive (e.g., enjoyment, pride, and

hope) or negative (e.g., anxiety, anger, and boredom), and they can be frequent and intense. Some of these emotions are brought into the classroom from life outside school, but most originate within classroom settings (Pekrun 2006).
Emotions are of educational importance for two reasons. First, emotions can affect students' interest, engagement, and achievement, as well as the social climate in classroom (Pekrun, Goetz, Titz, and Perry 2002). Second, emotions are central to psychological health and wellbeing, implying that they should be regarded as important educational outcomes in themselves, independent of their functional relevance (Fredrickson 1998). Both reasons have impact on students' learning. In this chapter, we focus on the former that is on how emotions can affect students' interest in science. Interest refers to a psychological state which has both affective and cognitive components: it includes emotions and valuing of disciplinary content (e.g. biology), as well as the perception of having and being able to develop knowledge about that content (Renninger and Hidi 2011).

Emotions that relate specifically to academic learning and classroom instruction are defined as academic emotions. Students' academic emotions are related to studying, test taking, and attending class. According to Reinhard Pekrun (2006) academic emotions can be categorized into four groups:

1) *Achievement emotions* relate to achievement activities and to success and failure resulting from these activities. Examples are enjoyment of learning; hope and pride related to success; and anxiety and shame related to failure. Achievement emotions are pervasive in academic settings, especially when the importance of success and failure is made clear to students.
2) *Social emotions* relate to teachers and peers in the classroom, such as sympathy, compassion, admiration, contempt, envy,

anger or social anxiety. These emotions are especially important in teacher/student interaction and in group learning.

3) *Epistemic emotions* are emotions triggered by cognitive problems, such as surprise about a new task; curiosity, confusion and frustration about obstacles; and delight when the problem is solved. Epistemic emotions are especially important in learning with new, non-routine tasks.
4) *Topic emotions* pertain to the topics presented in lessons. Examples are enjoyment of performing inquiry-based hands-on (Palmer 2009), and disgust when dealing with heart dissection (Holstermann, Ainley, Grube, Roick, & Bögeholz 2012).

Activating positive topic and epistemic emotions, such as enjoyment of learning the material, are assumed to trigger interest, strengthen intrinsic motivation, and deactivating negative emotions, such as boredom (Pekrun 2006). In the following, we discuss the conception of interest and the relation to emotions.

2. Interest and emotions

Interest is defined as a positive cognitive and affective experience that directs attention to, and focuses it on, the activity or task at hand (Rheinberg 2008). Interest is content specific, such that it is always directed towards an object, activity, field of knowledge, or goal. When persons experience interest, their actions acquire an intrinsic quality; they are driven by enjoyment rather than external reasons (Krapp 2002). However, it is important to note that interest cannot be equated with “enjoyment while learning.” Enjoyment can occur for many reasons, and interest is only one of these as we will outline in the section of different domains of interest that is presented later. Interest creates the urge to explore, take in new information and experiences, and expand the self in the process. It is commonly assumed that promoting interest increases students’

intrinsic motivation to learn and the number of learning strategies they use to do so (Hidi and Renninger 2006).

Interest is an important affective variable that is associated with focused attention, higher cognitive functioning, and learning (Ainley, Hidi, and Berndorff 2002). The experience of being interested is characterized as an optimal state that combines positive emotions, e.g. feelings of immediate enjoyment, and positive cognitive qualities, e.g. striving for meaningful goals (Rathunde and Csikszentmihalyi 1993). In recognizing the strong affective component of interest, many researchers went so far as to argue that interest is a basic emotion (e.g., Izard 1977). Suzanne Hidi (2006) suggests that if we only consider the moment in which the psychological state of interest is triggered, interest may be appropriately considered as an emotion. However, as interest develops and is maintained, both affect and cognition contribute to the experience. Furthermore, the relative strength of the two components of affect and cognition change over time, cognition having an increasing presence as interest develops (Hidi and Renninger 2006).

Topics of interest are generally characterized as those that students perceive to be personally meaningful. In science classrooms, interest is often associated with a particular science topic (e.g., Hoffmann 2002). It may be that a student enjoys learning about science and attending science class; however, the student may experience boredom if the content is not perceived to be meaningful.

In the following section we first give a brief introduction to the traditionally view on the interplay between learning as the cognitive side and interest representing the affective variables. Then we explore the involved concepts of affective variables, emotions, and interest development where we gather and marshal arguments for

another perspective on the interplay between learning and interest. The theoretical outline will then be exemplified from our empirical studies on interest development in upper secondary biology classes. Finally we will discuss the implications of our theoretical and empirical approach as well as the generality to use the approach outside science education.

2.1. ***Interest as a facilitator for learning***

Interest has a long history in educational research. For example, early educators such as Johan Friedrich Herbart (1965), and John Dewey (1913) pointed to the importance of interest for supporting learning. They noted the importance of interest in encouraging effort, focused attention, and persistence to understand content and that the design of tasks was likely to promote learners' interest in content to be learned.

Interest is conceptualized by most researchers as a phenomenon, which emerges from an individual's interaction with his or her environment (e.g., Krapp, Hidi and Renninger 1992). The etymology of the term inter-esse, 'between-being', points in the same direction (Dewey 1913). Interest is defined as a positively cognitive (involving knowledge and experience) and affective experience (involving positive feelings and appreciation) that directs attention to the activity or object at hand (Rheinberg 2008). Interest is characterized by focused attention and engagement, and the feeling of pleasure, happiness and well-being are typical emotional aspects of interest-based activities (Schiefele 1991). Suzanne Hidi and Judy Harackiewicz (2000) argue that students, who are interested in a particular subject, exhibit greater attention, are more persistent, feel greater joy and learn more than students who do not have this interest.

The close connection between interest and learning is by many seen as self-evident; the more interest a student has in a particular topic, the more willing he or she is to learn about that topic. Alternatively, those who have little interest in a discipline, tend to learn less. More specifically, interest affects goal setting and learning strategies in ways that make it a particularly relevant variable for improving educational practice (Hidi and Renninger 2006). It is generally assumed that interest is a motivational variable for learning: it induces learners to persist with a task, even if it is a difficult one; it focuses their attention on the task, and it produces positive affect regarding the task and the result of this is learning.

3. Interest development in theoretical perspectives

When looking at interest as a theoretical topic it is common to see interest appearing in three distinct domains involving a subject, an object, and an action. These domains are: i) dispositions, ii) interestingness, and iii) the psychological state of interest (Krapp et al. 1992). In the following section we will outline these three domains. In doing this we are also referring to their relations to their affective variables. After this short outline of each of the domains we will combine the three domains to learning in order to describe some of the interplay between cognition and affection in learning and interest development.

3.1 Interest as disposition

We all have dispositions for getting involved in and with different kinds of objects and activities. When interest is understood to be a disposition, it is therefore a domain involving a subjective perception, recognition and interpretation of an object combined with the will to act upon it. Whereas the first part involves cognition

the latter involves affection and thereby goes beyond cognition. The will to act is in other words a matter of affectional involvement with the perceived object. The affectional involvement is therefore motivated but not necessarily as an interest in the object.
Involvement with the object could be either a unified or a divided activity (Dewey 1913). When the activity is divided it is not the object in itself that is of interest but instead the fulfilment of others goals e.g. the teachers while a unified activity is an activity for the sake of the object. So even though both kinds of activities leads to the fulfilment of a goal there is a great difference in the affective state involved in those different forms of activity. Although divided activity calls for will power and maybe fear of the consequences for not fulfilling the goal a unified activity involves joy and positive expectations on the goal fulfilment. It is in the unified activity that we find an interest in things and it is therefore in dispositions that lead to recognition of possible unified activities that we find interest as disposition. Such positive expectation of goal fulfilment and positive emotions of understanding can turn into pleasure and joy in working with the specific topic. Klaus Fiedler (2000) provides a model – the Dual-force model – for combining learning and affective variables during learning. One of the key components in this model is that it builds on our internal long term interpretations of emotional stages. The model refers to the constructivist thoughts of Jean Piaget in that it sees the involved affectional variables as negative when doing accommodation while the affectional variables are positive while doing assimilation. Positive emotions and feelings entails that there is a general drive where the individual investigate and become more creative with the task while there is an aversion or frustration in the negative affective variables that forces the individual to focus more on getting the task right and finding structure. This model is useful in seeing the understanding of a topic as a trigger for positive emotions.
In the dispositions we again find a division into two subcategories namely general biological dispositions and individually experienced

dispositions. It is outside the scope of this chapter to outline fully the differences but in short the general biological are characteristics of an object that draws the attention of the individual towards the object. Such characteristics are referred to as interestingness (see next section) but they are characteristics that in general draw the attention of people and therefore they are not tight up the experiences and values of the individual (Wolf, Bach and Waitz 2014). On the opposite there are the individual experienced dispositions. Such dispositions are based on prior experience with an object like or related to the current object of interest. As said the difference between these dispositions lies in the personal value of engaging with the object. Dewey (1913) stated that the individual seeks growth and if prior experience is that interacting with an object leads to growth then there is a disposition for engaging with such an object when faced upon again. Such a growth of mind stimulates enjoyment while experiences without growth on the other hand stimulate boredom and is not likely to create dispositions for further engagement. In such an understanding individual dispositions of interest are foundered on individual valuable experiences involving both cognitive growth *and* positive affective experience of value. So a claim here is that it is the personal value of learning that constitutes the emotional input in the individual to experience positive feelings towards learning in science. This implies that that object of interest contains some kind of substance that is recognizable for cognitive growth in the individual. This is the basis of the interestingness of the object.

3.2 Interest as interestingness

The specific characteristic of an object, that makes it interesting, is referred to as interestingness. When students are handling live earthworms in biology lessons, for example, some may find the activity interesting. Interestingness may here refer to the hands-on aspect of the activity or the ‘sliminess’ of the worms. Students have

dispositions for different perceptions and interpretations of some objects while others are of more general conditions. The concept of interestingness was first examined by Roger Schank (1979) who found that an object can contain three different factors to draw the attention of a subject. First of all if one's expectations were not fulfilled, secondly if some information was missing, and thirdly if the object included distinct themes like death, danger, power, or sex. Suzanne Hidi and William Baird (1986) describe the first two factors as context dependent while the last is cross-contextual content. Because the object is given in the context – and in school within the context of teaching – it is also given that the interestingness of the object is the only thing that an outsider can form and manipulate to have the subject to draw attention towards it. But because these categories are of general interestingness they also draw upon the general biological disposition from above. This means that there are factors that can draw a person's attention towards an object but this does not necessarily the object more interesting in a personal view. There is only limited personal growth involved in interacting with the object and drawing on such general interestingness is in the terminology of Dewey (1913) called sugar-coating or in a newer saying from game-based learning - chocolate covered broccoli (Habgood and Ainsworth 2011). It is not the object in itself that has interest but instead a general interestingness outside the actual object and by covering the object up in either sugar or chocolate we distract the students from seeing and valuing the object and instead digesting the cover and by doing so we actually introduce the students to a divided activity. As Dewey (1913) states: "When things have to be *made* interesting, it is because interest itself is wanting. (p. 11)." And interest in itself is not of value. The value connected to the individually experienced dispositions lies within the specific object and it possibilities to bring personal growth. It is therefore not enough to focus on the interestingness of an object to create fruitful affective stages in learning. In order to create a context containing interestingness there has to be congruence between the object of

intended interest and the object of attraction. If not so then the attraction is drawn in other directions and we will be back at the divided activity described above.

So in order to maintain interest there has to be to growth in perception and valuing of the object meaning that not only does interest work as a facilitator for learning, it is also going in the other direction where learning is working as a facilitator of interest. Here it is not enough to discuss if the object has some kind of interestingness. It is also a necessity to look at the quality of such an interestingness and if this interestingness is embedded in the object or introduced as a covering layer to have the students to swallow it.

3.3 Interest as a psychological state

Interest can also be a psychological state. Traditionally this state is divided in two parts namely a) situational interest and b) actualized individual interest (Krapp et al. 1992). Originally situational interest represented interest initiated from the interestingness of the object – including some of the general and cross-contextual factors from above – while actualized individual interest was initiated from individual dispositions to recognize content from prior experiences in the current object. Even though there has been substantial research focus on situational interest the concept of actualized, individual interest is almost neglected. This could be due to the fact that the differences between the two when observed in research are not clear. In fact they may be so similar that Paul Silvia (2006) proposed that the concept should be removed from research in interest because it was a pure theoretical construct that was not measurable in practice. Although research has been focusing on situational interest it seems hard to find a coherent approach from where to understand and investigate interest as a psychological state (Renninger and Hidi 2011).

The distinction between situational interest and actualized individual interest is in our context seen as fruitful in that it reveals the distinction between the different qualities of interest and interestingness.

Interest as a psychological state implies that there has been a connection between the subject and the object. Within some research literature this connection is often referred to as a catch (Mitchell 1993) or a triggering (Hidi and Baird 1986). The distinction between these two approaches lies in the direction of the connection where catch implies that the object has an interestingness big enough to catch the attention of the subject whereas triggering implies that the subject through dispositions encounter the object due to recall of prior experiences. Within research in science education there has during the last decades been a focus on triggering as the connection between the object and the subject (Renninger and Bachrach 2015). Again referring to the quality of the interest a catch may be seen mostly referring to the general biological dispositions while triggering is mostly an outcome of individual experienced dispositions. In order to constitute further the psychological state of interest there must be a hold of the attention and possible engagement from the triggering. Here Suzanne Hidi and Ann Renninger (2006) provide a model dividing this holding in two main categories namely i) situational interest and ii) individual interest. Situational interest is further divided into two subcategories of triggered situational interest and maintained situational interest. Both phases have in common that there is a need for outside support from e.g. a teacher to keep focus on the object and finding characteristics worth working with. Individual interest is also divided into two subcategories which are emerging individual interest and well-developed individual interest. In these phases the drive for engaging with the object primarily comes from the individual and thereby from the individual experiences dispositions.

Even though Silvia (2006) has a point about the practical investigations of interest it though seems the there is a need for a further distinction of concepts within the domain of interest as a psychological state. In the following section we will look at the interconnections between these three domains and link these connections towards emotions.

4. Connecting the domains of interest

There is a clear connection between going from the domain of dispositions and the domain of interestingness going towards the domain of interest as a psychological state, which is also described in research literature (Krapp 2007). What is not that clear is the reverse connection from interest as a psychological state towards interest as dispositions or as interestingness. The triggering/catch and the hold of an actualized interest give a direction of a somewhat momentary state of interesting interaction between the subject and the object but it does not give an explanation for the development of interest and the role of an actualized interest in this development. If the psychological state of interest is actualized and held we claim there can be a combined effect of the of the four-phase model of interest development (Hidi and Renninger 2006) and the personal growth of mind (Dewey 1913) involving both cognitive development and affective well-being.
The affective dimension may at start be negative as frustration or avoidance against a difficult task. In order to contribute to the development of interest, this negative affection must be turned into a positive which is what happens when the difficulties are overcome (Fiedler 2000). This can happen either as an ‘aha-experience’ with a sudden positive feeling (Bechara and Damasio 2005) or as a more slow understanding with a change in long term emotions (Linnenbrink and Pintrich 2004). In fact it is in the overcoming of difficulties that the positive emotions can establish and develop an

interest. As Dewey (1913) states:

> "It is not too much to say that a normal person *demands* a certain amount of difficulty to surmount in order that he may have a full and vivid sense of what he is about, and hence have a lively interest in what he is doing." (Dewey, 1913, p. 52)

This is yet another argument for reversing the connection between interest and affection. It is through the learning and the cognitive gain that the individual create the positive feelings toward an object. So our claim here is not only that the triggering/catch and the hold parts direct interest from the subject and the object towards a common domain of an active psychological state of interest. When this state is actualized it also feeds back to the other two domains in that the object is opened up and deeper layers of understanding become accessible while at the same time the active interaction with the object and the new dimension opening up is valued by the subject thereby strengthening the individual experiences dispositions for further engagement.

To sum up the theoretical approach we do not accept the common approach that interest is a facilitator for learning (Krapp 2002). Learning is also a facilitator for interest development.

Patricia Alexander (2004) proposed the Model of Domain Learning (MDL), which describes interest development in parallel to a person's increasing academic competence. Patricia Alexander, Jonna Kulikowich, and Tamara Jetton (1994) have shown that levels of individual interest and domain knowledge are highly correlated. Both situational and individual interests are included in discussions of the role of interest in the MDL. The MDL specifies stages of individual expertise development (and of concurrent interest development). Alexander suggested that the final stage of expertise is only reached after high school and that the stages of the MDL are sequential and irreversible. As a consequence, if a person is an expert, then he or she has an individual interest for the

subject matter domain. This also means that individual interest is not present before reaching expertise. The model has met critique in that Hidi and Renninger (2006) claim that individual interest can be present in much earlier stages and in younger students than post graduate high school students. We here agree with the critique but also keep in mind that the MDL does not have the intention to describe interest development but more to give a clearer view on learning thereby having a focus on cognition and not on affective variables

We found underpinning arguments for the view that learning may facilitate interest development through research on interest development in science education. In the following section we will show how students' experienced the affectional side of leaning. This is done through two cases where the empirical work thereby will underpin our theoretical statements on the directions and interplay between cognition and affection.

5. *Cases*

To illustrate our theoretical statements we here present two cases from upper secondary biology education. The combination of the two cases addresses the point taken in theory that learning can be a facilitator for interest development.

5.1 Learning to be interested: The case of animal physiology

The first case concerns an undergraduate biology course in animal physiology (Dohn, Madsen and Malte 2009). Students' situational interest was investigated by observation, informal conversational interviews, and a questionnaire. Students described what had caught their interest in previous lessons (lectures, theoretical exercises and laboratory exercises) and described why they found

the situations interesting. The aim was to explore students' perceptions about sources of interest.

Knowledge was a very important source of interest in this study. Knowledge-based interest was identified at two levels; 1) *aha-experiences*, and 2) *background-knowledge*.

When a student is 'stuck' on a problem, he or she sometimes achieves a clear and sudden solution through insight – the so-called *aha-experience*. Aha-experience refers here to a knowledge-based interest that is triggered by a sudden and unexpected flash of insight. For example, a student stated that "it was really fascinating when I suddenly realized how muscles function".

The experience of being interested seems to be the consequence, rather than the cause, of the intellectual activity involved in resolving some issue. An explanation of why aha-experiences can trigger interest must be sought in closely related variables like optimal challenge, novelty, and optimal discrepancy between input and cognitive structure (Deci, 1992). The aha-experience is situated in the context of problem solving. As such, the first step towards promoting the aha-phenomenon is to present students with interesting and challenging problems.

One of the most common interview responses was that interest emerged by acquiring knowledge in physiological processes and how these processes are expressed in different living animals in comparison with human beings. The responses refer to a knowledge-based interest which is generated due to relevant background knowledge. This category has much in common with aha-experience but is much more persistent and of more individual character.

In a study by Patricia Alexander and Karen Murphy (1998), the undergraduates demonstrated significant growth in domain knowledge and were more personally interested in that domain, which suggest that knowledge and interest should be significantly and positively correlated.

According to Patricia Alexander, Jonna Kulikowich, and Sharon Schulze (1994), there appears to be a reciprocal relationship between knowledge of a domain and interest in the domain. That is, we pursue learning about things we are interested in, and the more we know about something, the more we become interested in it. Previous research suggests that background knowledge is related to both individual and situational interest, even though knowledge appears to be related more strongly to individual interest (Bergin 1999). In the study of David Palmer (2009), learning (i.e., the acquisition of domain knowledge) was found to be the most important source of situational interest among K-9 science students.

From an educational point of view, the major challenge is how educators can help students in the acquisition of domain knowledge and thus interest. Unfortunately, background knowledge is a factor which is difficult to change, because it is predominantly an individual variable. As Dewey cautioned decades ago (1913), transient (i.e. situational) interest alone will not sustain learning, and such sustained learning is requisite for proficiency in any complex domain. Thus, abstract, demanding exposition will need to be carefully anchored to the goals and long-term interest of students (Alexander, Kulikowich and Jetton, 1994). Findings from studies of interest suggest that educators can help students sustain their attention towards tasks even when these tasks are challenging. This could either mean providing support so that students may experience a triggered situational interest or providing feedback which allows them to sustain their attention, generate their own questions and select resources which promote problem solving and

strategy generation (Hidi and Harackiewicz 2000; Schraw and Lehman 2001).

5.2 Learning to be interested: the case of simulating natural selection

As shown in the above case on animal physiology it was found that knowledge and new learning could be what the students found interesting. In another study on this topic was approached more directly (Petersen 2012). In Morten Petersen's (2012) study students at upper secondary level was doing a simulation in natural selection. All students had on forehand read and had lessons within the area of natural selection and evolution and the simulation was therefore not introducing new knowledge but instead getting prior knowledge more consolidated.
The approach in the study was to test the development of conceptual understanding of core concepts of natural selection and evolution addressed through the simulation. Students who showed development in the direction of a more scientific understanding of either one of these concepts were then interviewed afterwards specifically addressing their experiences on learning and understanding these concepts and their emotions in doing so. The target group of students informing the project was therefore limited to students who showed signs on having cognitive expansion of the prior understanding.
In this exploring of interest development through learning it became clear that every student interviewed in the beginning found it hard to cope with the simulation of natural selection with Lego® bricks which was the material for modelling (Christensen-Dalsgaard and Kanneworff 2009). When the students started working with the simulation they saw the bricks for what they were – bricks. But after working with the simulation almost every student changed perception from seeing a pile of bricks to seeing small animals. This change of perception is what we argue for as an essential part of

interest development in the theoretical approach to interestingness and the interplay between interest as a psychological state and interest as interestingness.

In the follow up interviews students connected this change of perception to the understanding of not only the exercise but also natural selection in general. Even though the students have had lessons in natural selection on forehand almost all students experienced a deeper understanding of the concepts involved in natural selection and especially the interplay between these concepts. It is through this change of perception that we find not only a shift in emotional state from slight frustration and lack of understanding towards understanding and enjoyment but also an unfolding of the object – in this case the bricks – helping the students to realize personal growth through this deeper understanding.

When discussing the research set up with colleges a common critique was that because almost every child have had good experiences with Lego® bricks it would be the bricks that caught the students' interest and not the biological simulation of natural selection. In other words the bricks would have a function as sugar coating or cholate cover and thereby lowering the quality of the perceived interest in the students. But when confronting students with this critique in the interviews it turned out that many actually disassociated from the bricks in that they felt that they in upper secondary school were too old to use toys. This disassociation thereby confirms to us that when the interest is present it is also present in a quality that could be seen as an actualized individual interest. This means that when we find interest it is due to that biological domain knowledge in the simulation and not due to the recall of childhood play with bricks.

As seen in the former case students experience new knowledge in different ways as either aha-experiences or as background knowledge. In the case of natural selection this is also the case but some of the students report that they actually had an aha-

experience but that this experience did not happen during the exercise but when they were working with their written protocol of the exercise that they had to hand in. This indicates that even though the students were capable of showing progression in their conceptual understanding from the pre-test to the post-test this new knowledge did not reveal itself to the students as explicit knowledge until they again had to work with the concepts and knowledge of the simulation.

Such a delay of understanding and revealing of knowledge is also found by Kevin Pugh (2011) in the investigation of transformative experiences and actually the simulation of natural selection led many students towards such transformative experiences. The understanding of the concepts involved in natural selection and their interplay did not only open up as deeper knowledge. It was also valued knowledge for the students making some of them see their everyday life in a new perspective. So the findings of the study indicate that there from the actualized interest is a feedback to both the object as deeper understanding and to the subject and thereby the dispositions in valuing this new deeper understanding.

We thereby find empirical evidence that the process of learning and interest development in science education is not a unidirectional process but can be viewed upon as an interdepend process similar to the intention with the MDL of Alexander (2004) but also taking the critique from Hidi and Renninger (2006) into account in that we find an interest well foundered in individual dispositions even though the students may not be experts in the domain of biology and evolution.

6. Perspectives of focusing on interest development

In this chapter we argued that the connection between affective variables in interest development and cognitive processes in learning is not a unidirectional connection but rather a connection that can be both interest as a facilitator for learning and learning as

a facilitator for interest development. Through our theoretical outline we have shown that even though the common approach to the connection between interest and learning is that interest is a facilitator for learning we can as well find arguments in the research literature for the opposite approach seeing learning as a facilitator for interest development.

Throughout our argument we have also discussed the quality of the interest in the sense that the object of interest has a need for an inbound possibility of unfolding itself to the individual through learning and understanding instead of the object being covered in stimuli for drawing attention towards the object. In order for an object to entail true interestingness the object has to offer possibilities for personal growth and valuing of this object. If there is no learning and personal growth during an activity the individual may hold the activity for a while but the activity will not contribute to strengthening a future engagement with similar content.

Through our empirical work we found that not only do university students in biology find it interesting to learn through either aha-experiences or through background knowledge in the case of animal physiology. Students in the case of natural selection actually find that the deeper understanding of the interrelation between previous learned concepts is the core in getting an interest woken up. The empirical work thereby goes hand in hand with our theoretical outline in questioning the unidirectional connection between interest and learning.

Through our theoretical and empirical argumentation we highlighted learning as having the qualities of understanding, cognitive growth, value, and transformative experiences. So in order to go beyond the cognition in learning this learning has to be a deep learning going from learning *about* biology towards a learning *of* biology (Scardamalia and Bereiter 2006). Such deeper learning is more time demanding than an introduction to topics without this deeper understanding and thereby leaving the teachers with a challenge towards fulfilling a standard curriculum if students need. From our

previous arguments with reference to the dual-force model (Fiedler, 2000) we can state that such a lack of time for getting to understand the topic may in the worst case introduce students to a long term emotional state of negative emotions without having the time at hand for the students to follow the emotional progression in understanding towards a more positive emotional state. Such an experience is not likely to enhance the development of an interest. In fact an experience of that kind would be capable of drawing students' attention in other directions than science in that they experience the lack of personal growth.

A critique of such arguments can be that we thereby are postulating that a person cannot be interested in something unless this involves deep learning and understanding. We do not mean to exclude short term positive engagement with objects as not being interesting to the person but in order to contribute to the personal growth and the valuing of the content the interaction needs to be over a period long enough for the object to open up towards seeing new dimensions of it. Here the short term engagement can be placed as situational interest that can be held through general biological dispositions and covering the objects in such interestingness is a distraction from an object not unfolding itself.

In this chapter, we have concerned ourselves with biology students in upper secondary school and at university. It should be kept in mind that, to the extent that the results are generalizable, they might well hold only for similar populations. It is likely that different emotional and motivational dimensions would emerge with different populations and in different subjects. Replicating this study with different populations, not least ones with younger students would be an important next step.

Despite these limitations we would like to pinpoint our main claim in this paper once again. We have argued that not only can interest be a facilitator for learning. It also goes the opposite direction in that learning can be a facilitator for interest development. For a practical implementation of our claim a teacher is therefore not in a need for

focusing on interest in itself for getting motivated and interested students. A focus on learning and understanding of content knowledge can also be a way for students to get a positive affective experience with learning and thereby go beyond cognition.

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