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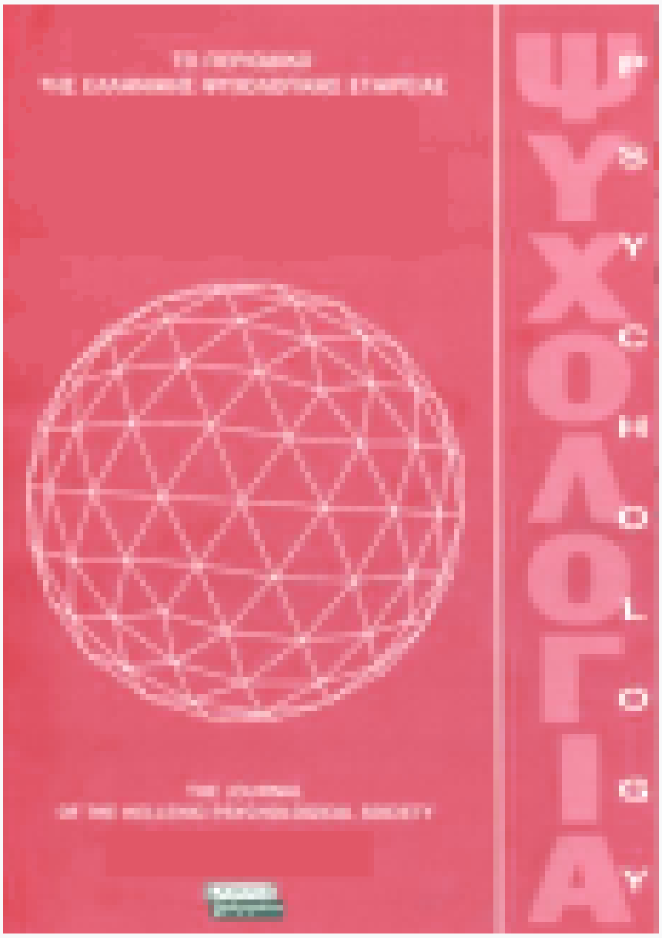

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Self-concept reflected in students' activities during physics instruction: The role of interest-oriented actions

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ABSTRACT Individual student learning processes are investigated at the Institute of Physics Education. Our observations have shown that students' attitudes towards physics and other elements of their self-concept relevant to physics lessons have an influence on their actions and their learning processes. The investigation concentrated on individual interest as one element of self concept. The evaluation was based on classroom video observations, interviews and questionnaires. By using a theory developed by Krapp (Krapp & Fink, 1992) it was possible to identify interest-oriented actions which helped to identify activation of different compositions within the working-self. The results of an 8th grade case study is presented to show the interplay between self-concept, students' actions within the classroom, and their learning processes.

Keywords: Interest, Learning process, Self-concept.

This paper presents an approach to analysing learning processes in physics lessons through the observation of students' performances. We explain the methodology by which we tried to examine students' classroom activities by taking into account theoretical perspectives of the self-concept. In the past this particular research domain predominantly considered learning as a result, or process, of cognitive development. Variants such as the self-concept, motivation, self-esteem, etc., were not assumed to be relevant when learning processes were analysed, and aspects of personality such as motivation were often reduced to a kind of energy responsible for initiating student activities. On the other hand, motivation was seen to activate cognitive development but did not seem to have any significant influence on the result of the learning process.

Modern thinking on learning and development has been based heavily on cognitive psychology. Previous research on student cognition focused on demonstrating that prior conceptual knowledge influences all aspects of their information processing; from their perception of the cues in the environment, to their selective attention, encoding and levels of processing information, and search for information (Alexander, Schallert, & Hare, 1991). The cognitive models developed are useful and relevant if learning is to be conceptualised. However, their reliance on a model of academic learning as "cold and isolated cognition" (Brown, Bransford, Ferrara, & Campione, 1983) may not be applicable when one

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describes learning in a classroom context. In recent years, theory and research on learning has shifted more or less from passive models of individual functioning to models that include individual goals and aspirations, the ability to develop and change strategies of actions and the knowledge about the self and the environment, etc. (Krapp, Hidi, & Renninger, 1992). Strike and Posner (1992) mentioned that "a wider range of factors need to be taken into account when attempting to describe a learner's conceptual ecology. Motives and goals and the institutional and social sources need to be considered." (Strike & Posner 1992, p. 149).

Individual's actions are based on cognitive processes (Pekrun & Helmke, 1991). Self-related cognitive concepts and information are important for these actions. They influence individual actions, sometimes unconsciously, in different phases of the action process (Filipp, 1979; Markus & Wurf, 1987). The subjective belief in self-competence, for example to cope with situations of great demand, is a main parameter of the type of student's action in schools (Buff, 1991).

Previous investigations have shown that students' self image, self-esteem, interests, self-confidence in their own ability, their relationship with science and former experiences with the subject, strongly influence their learning processes (Hannover, 1991; Hoffmann & Häussler, 1997). The actual content of student's theories and models of knowledge is influenced by personal, motivational and social factors, as shown by the existence and persistence of students' misconceptions in science. On the other hand, Jerusalem and Schwarzer (1991), for example, demonstrated in a longitudinal study that the development of students' self-concepts is influenced by their learning environment. It is important to remember that this study considered only (school-) subject-independent self-concept elements. Subject- and domain-related self-concepts were not analysed. Nearly all of the results came from questionnaires or from laboratory studies in a very specific learning environment.

One of our research interests was to investigate whether it was possible to observe influences from elements of the self-concept directly from student activities and learning processes while they performed in a *normal school environment*. We therefore analysed their behavior and activities in the classroom and identified the interactions of the so called working-self with their activities and learning processes, whilst taking into account the constructivist position that the process of learning is influenced by personal, motivational and social processes.

The self-concept

The individual gains much from his or her socialisation, not only from his or her experiences within the social and material surroundings, but also from the acquisition of knowledge and information about themselves, through self-observation, interactions and social comparison. Self-concept is therefore probably vastly different from any description provided by an independent observer. Once internally developed, the self-concept influences the perception, expectations and activities of the person.

There are many definitions of the 'self-concept' differing, for example, in its structure and the way it works. In addition to this, all of these theories use different terms to describe the elements of this phenomenon, such as self-concept (Shavelson, Hubner, & Stanton, 1976), self-schema (Markus, 1977), and self-representations. However, one of the few points common to these theories is that the self-concept is seen as a structure or product of elaborated self-related information drawn from different individual experiences, especially information pertaining to their own body, abilities, knowledge, interest, feelings and behavior. All of this information is organised into clusters depending on the context. Hannover (1997), for example, described the context-dependent clusters as self-constructions, and suggested that all of these clusters combine together to build up the self-concept. Individuals differ in respect to the availability of self-related information, based mainly on different experiences and the depth of the elaboration of these information clusters.

The particular definition of the self-concept adopted in this investigation is based on the theory proposed by Markus and Wurf (1987). They developed a model of a dynamic self-concept (Figure 1). The self-concept is viewed as a collection of self-schemata, and the working self-concept is that subset of schemata which is accessible at a given moment. On the one hand, which self-schemata are activated depends on the social circumstances and the individual's motivational state. On the other hand, the structures active in the working-self are the basis by which the individual initiates actions, and they are also the foundation for observation, judgement and evaluation of these actions.

The influence of the working-self can be seen in two broad classes of behavior: (i) *intrapersonal* processes, which include self-relevant information processing, affect regulation, and motivational processes; and (ii) *interpersonal* processes, which include social perception, social comparison, and interactions with others. The outcome of one's *intrapersonal* and *interpersonal* behavior determines the current motivational state and the salient social conditions for the next cycle of self-regulation.

We diverged from the Markus and Wurf theory, in that we did not use the term 'self-schemata' to describe an element of the global self-concept. In reference to the critique by Hannover (1997) on the self-schemata concept used in this project, we use the term 'self-related cognition' to describe the elements of the self-concept. Hannover (1997) mentioned that the schemata term is too broad and complex. An individual may not have a schema for several topics, but there is still

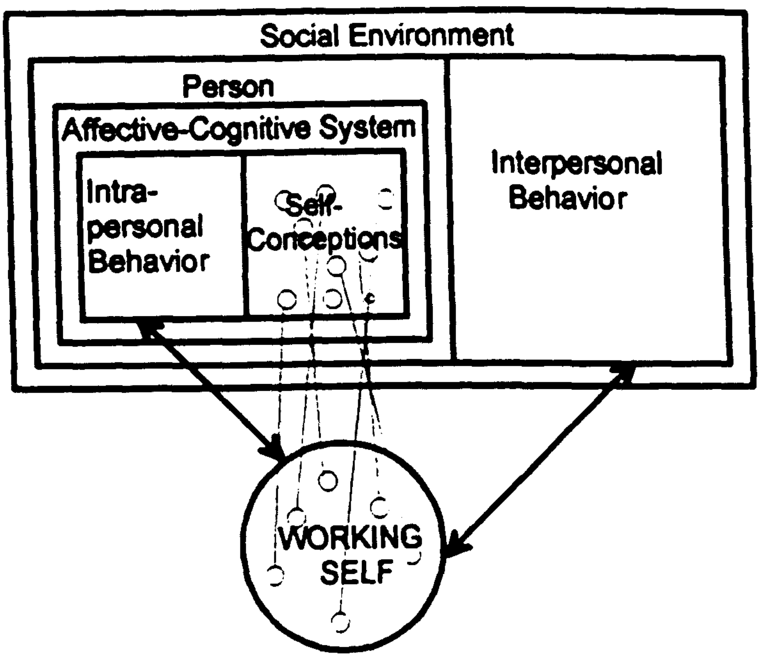

Figure 1: The Dynamic Self-Concept[1]

Note 1: From "The dynamic of self-concept: A social psychological perspective" by H. Markus and E. Wurf, 1987, Annual Review of Psychology, 38, p. 315. With permission, from the Annual Review of Psychology, Volume38, " 1987, by Annual Reviews probably some information relating the individual, context and topic. In conclusion, we define a self-concept as a memory structure, in which all self-related cognitions are represented. For each individual context the cognitions are organised in clusters, called self-constructs (Hannover, 1997). The self-concept for different individuals differs not only in the available self-constructs, but also in the accessibility of these self-constructs. The more frequently a special self-construct is activated, the better and more quickly it becomes accessible. The working-self consists of a special selection of active self-constructs, the configuration of which depends on the activation source. The stronger the accessibility of a particular self-construct the higher the probability of activation of this self-construct through a special activation source. The working self controls the processing of new information and the individual's behavior. The self-concept also includes representations of 'possible selves', which show the cognitive aspects of the individuals' aims, hopes and fears (Markus & Nurius, 1986).

It is obvious that it is almost impossible to investigate and observe all of the self-constructs of an individual. At the beginning of the project it was therefore necessary to concentrate our observations on only a few elements of the physics-related self-construct. We decided to examine interest as a main part of this self-construct. Researchers into 'interest' (Krapp, Hidi, & Renninger, 1992) have already mentioned that interest has a positive effect on learning processes. However, there has been little research carried out on interest and student cognition in science. Basic text reading was also investigated (Hidi & Anderson, 1992). Krapp, Hidi, and Renninger (1992) also investigated interest and learning processes in the school environment, and support the assumption that interest forms a main

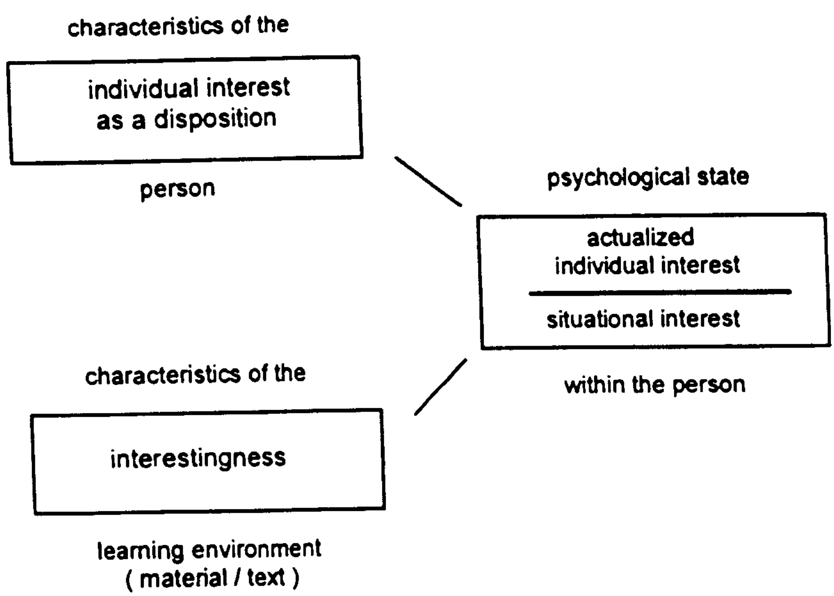

Figure 2: The concept of interest[2]

Note 2: From The role of interest in learning and development (p. 10), by K. Renninger, S. Hidi, & A. Krapp, 1992, Mahwah, NJ: Erlbaum. Copyright 1992 by Lawrence Erlbaum Associates, Inc. Reprinted with permission of the author.

part of the self-concept.

More specifically, the importance of a task seems to be related to the individuals' self-constructs. If a student sees him or herself as becoming a scientist -this scientist-concept can be seen as one of his or her possible selves (Markus & Nurius, 1996)- then scientific contents and tasks may be perceived as being more important, regardless of his or her mastery or performance during science learning. As a first step in this study we therefore decided to investigate interest as a part of the physics-related self-construct, and the influence it has on students' behavior in the context of the classroom, by identifying and analysing interest-oriented actions.

The concept of interest

In general terms there are several definitions of the term 'interest'. However, there are two common attributes in all of these definitions. Interest relates to things, objects which are outside the person. Interest also designates personal preferences. Figure 2 illustrates three main lines of research into interest. They are (1) interest as a characteristic of the person (individual interest), (2) interest as a characteristic of the learning environment (interestingness), and (3) interest as a psychological state.

Both individual interest and "interestingness" can be the source for a psychological state in which an individual can be described as interested. Typical characteristics of this state might be positive feelings, increased attention and willingness to learn. "Interestingness" is the factor which can be arranged by the teacher during a lesson. During our investigation we observed how students react according to their individual interest and the "interestingness" of the situation. We wanted to clarify whether it was possible to distinguish between 'normal' student activity during the lesson and actions activated through interest. Krapp (Krapp & Fink, 1992) defined 'interest' as a special relationship between a person and an object (e.g., a theme or subject). This special person-object-relationship can be observed through an activity (an 'interest-oriented action'), or through 'personal or individual interests' based on habitual structures. The interest-oriented action is close to the current behavior and action of the student; therefore it should be possible to identify these actions during physics lessons. The definition of an 'interest-oriented action' as described by Krapp, contains three characteristics, namely:

(a) *Cognitive stabilisation:* The person has a great knowledge of the object and has an extensive repertoire of possible actions when he or she deals with the object. However, it is necessary for the person to gain more knowledge about the topic.

(b) *Emotional status:* Interest-oriented actions are always accompanied by positive, agreeable and stimulating feelings. These are feelings such as joy, agreeable tension, 'flow-experiences', competence, self-determination and social integration. Integration and acceptance are very important facets, especially when the individual acts within a group.

(c) *Personal value of the person's interest-action:* In the current interest-action the personal value component can be investigated through the 'self-intentionality' of the action the person is performing. It is possible to describe an activity as self-intentional when the person can plan and carry it out independently. The action does not need to be arranged by anybody else. The interest, the occupation and dealings with the object are important and valuable to the person. This finds its expression in a high position of the object or topic within the individual's value hierarchy.

Aims

The question which is at the centre of the research done in our Institute is: 'How can students' learning processes during instruction be described, and what influences them?' It is obvious that cognitive processes can't be observed directly. An observer can only analyse students' actions and their verbal statements, while, e.g., the students are doing an experimental task. From these data the cognitive processes must be reconstructed.

As described in the theory of the self-concept, actions, perception and expectations depend on the working-self. For that reason we cannot define students' actions independently from their self-concept. Self-constructs that are activated in the working-self are the basis from which a person initiates actions. These activated self-constructs are the foundation of observation, judgements and evaluation of the actions of a person. On the other hand, the situation also has an influence, so that self-constructs are activated in the working-self. From this point of view the actions of a person are also determined by the situation. The knowledge of the influences of self-constructs on students' actions could help to achieve a better understanding of the students' activities during instruction.

In this study we want to show if it is possible to identify activated self-constructs and to analyse different compositions of the working-self while students' actions are observed. A special class of action, the so called interest-oriented actions, are in the focus of the investigation. These actions can be determined according to the characteristics given to them by Krapp, and so we will be able to distinguish them from the students' other actions.

During an interest-oriented action the working-self of a person should have a different composition than during a 'normal' action. As elements of a physics-related self-construct we could identify through our research, e.g., the following elements: interest in physics, self-confidence in their own ability, relationship with science, gender-related role-models, etc. In this paper we are focusing particularly on the appearance of physics interest-related self-constructs in the working-self.

Method

Design

The following sections present an example of our analytical and interpretative work in a condensed form. They also explain our research methodology and demonstrate the kinds of results we got from our investigation.

Classroom setting. The investigation focused on a 20-week physics course, with an 8th grade gymnasium class (approximately 14 years of age). The subject matter was electricity, using a water analogy (Schwedes & Dudeck, 1996). A main element of the teaching method was the 'play-oriented approach' that was developed at the Institute of Physics Education, University of Bremen (Aufschnaiter & Schwedes, 1989). Play-oriented means that the pupils work on self-elaborated questions, or independently plan and carry out experiments based on their own ideas

Table 1
Indication for analysis of behavior related to interest-oriented-actions (extract)

verbal	non-verbal
• Most statements consider the task and topic • Statements express joy • Statements concern the importance of the task and actions • Statements which show deeper enquiry • problem solving • Statements which show that the individual wants to know more	• Absolute concentration on the task and topic • Only action and behavior which is necessary for the task and has a relation to the task • No reaction to disruption • Variation of the task

and hypotheses. Short teacher-oriented phases alternate with long action-oriented phases. This didactic concept was useful in following individual students' actions and learning processes. The students' actions were self-controlled and it was probably possible to identify their real interests or non-interests in the lessons or subject as a whole.

Data collection. During the lessons video recordings were made of the activities of two student groups and of the personal interviews with the students. Elements of their self-concept had previously been determined through interviews and questionnaires. Sections were selected from the video recordings for analysis. These scenes were subsequently transcribed, i.e., into linguistic and visible facial expressions, and physical actions were documented. The main part of the data interpretation consists of the reconstruction of students' 'ideas' from the transcribed sequences. A special method of content-based analysis was developed in our Institute at Bremen University. The method cannot be explained in detail here, but more information can be found in the paper published by Welzel (1998).

In a first step, single actions including verbal statements are identified. For each action, observation, hypothesis or explanation from the students, the observer constructs the underlying idea. In this way students' cognitive processes are reconstructed based on the observed action and statements. Chronological lists of 'ideas' for each student are the result of such interpretative processes. The criterion for appropriate interpretation is the consistency of the sequence of 'ideas'. Generated physics-related 'ideas' were categorised according to their complexity to describe the learning process (Welzel, 1998).

When recording the interplay between elements of the self-concept and cognitive structures during the learning process, it became obvious that more than just student task-related actions had to be observed and analysed. Therefore the reconstructed 'ideas' from all students' actions had to be analysed according to their relevance to the learning process -which means the complexity of the 'ideas'- and to their connection with the identified elements of the self-concept of the students.

Our paper concentrates on the presentation of more detailed analysis of students' actions, especially interest-orientated actions, observed during group work sequences and not on their cognitive development. The reconstructed 'ideas', together with the other information of the transcript, helped to identify interest-oriented actions in relation to the previously mentioned characteristics of these actions. A short summary of important characteristics can be seen in Table 1.

Results

Data presentation

To demonstrate a more detailed outline of our analytical method, we will explain in detail the analysis of a sequence of tasks. For example, the 4th lesson of the unit 'water and current' is described. Three girls: Nadine (NA), Corinna (CO) and Caroline (CA), constitute a group in the physics course.

Presentation of the students. As a result of the personal interview and analysis of the questionnaire, a deeper understanding of the elements in the students' self-construct was gained. This short summary introduces two students: Nadine and Corinna. We chose these two girls as they worked in the same group, and because they had totally different levels of interest in physics. Nadine described herself as being very interested in physics and science. On the other hand, Corinna had no interest in physics or science at all. Both were good students. The following more detailed description provides an understanding of their actions and behavior in this particular school lesson.

In summary, we can state that Nadine possessed a positive physics self-construct. She enjoyed natural science and described herself as being talented in this area. In one interview she described how she repaired a vacuum cleaner step by step and how she helped her brother to install electrical wiring in their new house. Her career aspiration is to become a pilot. However, Nadine had a negative social self-construct. She

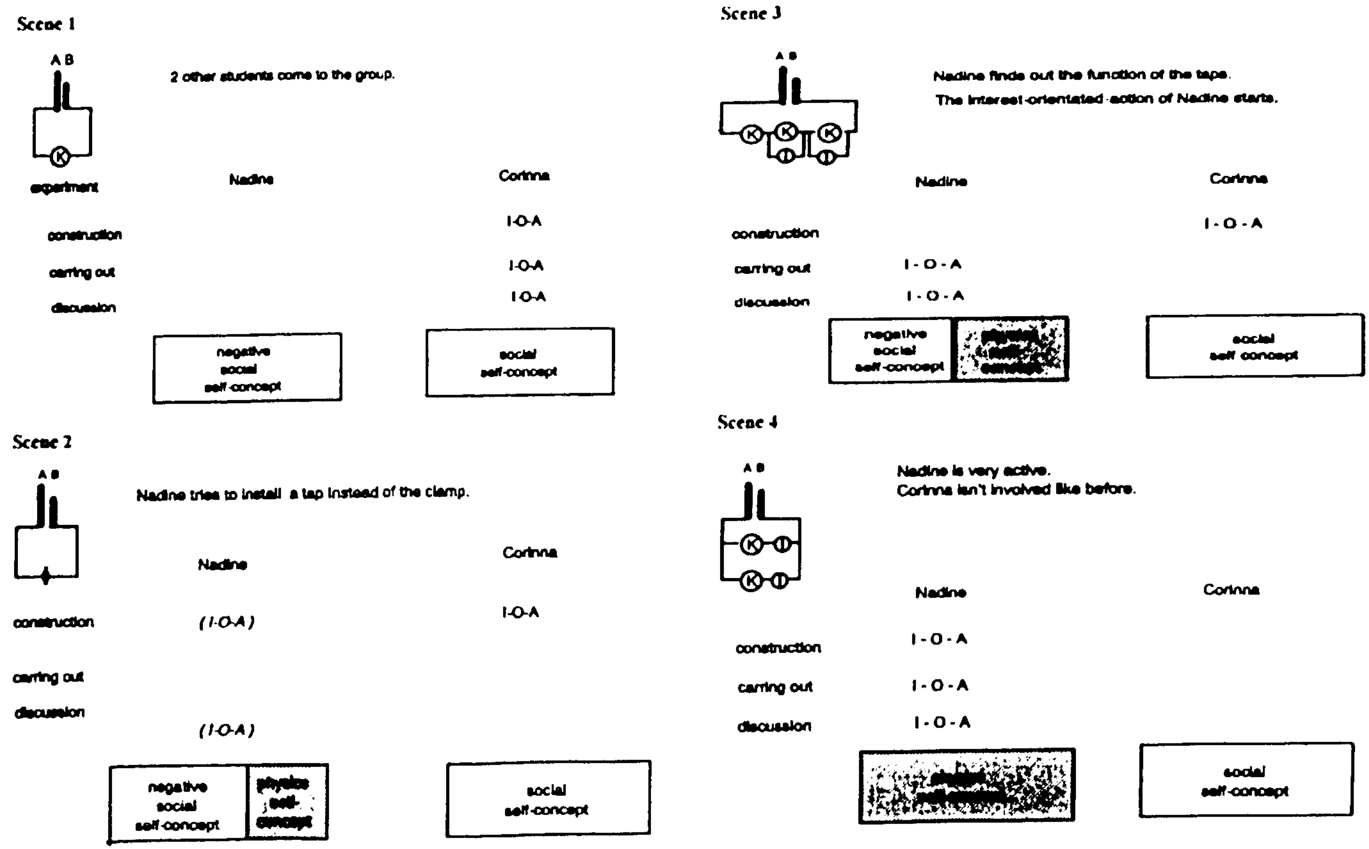

Figure 3:
4th lesson: Students' actions and behaviour explained through interest-oriented actions (I-O-A) and the composition of the working self

felt that she was not accepted by the rest of the class and was consequently not very popular with her classmates. She described herself as shy and anxious. These illustrations are only a few of the characteristics that describe 'Nadine' as a person according to her elements of these two self-constructs.

Because of her positive physics self-construct, it would be reasonable to expect Nadine to be very active during a physics lesson, especially where a great deal of student experimental work was carried out. However, Nadine was mostly observed to be more passive than active, and more in the role of an assistant to her group members. Only in special situations did Nadine behave in the expected way: i.e., deeply involved in interest-oriented actions. The reasons for her interest-oriented actions and how they were accompanied by the activation of a different composition of the working-self were investigated.

Corinna did not have any interest in physics. She did not describe herself as unintelligent, but believed she was not talented in physics. In comparison with Nadine she possessed a negative physics self-construct. In her opinion, it was not necessary to be good at physics. "You only have to be intelligent to understand a task in a physics lesson", she said and added, "And I am not stupid." It was important for her to be a good student and therefore she was active in the lesson. She only wanted to find a solution to satisfy the teacher's request and to get a good mark and she was not interested in complicated questions. On the other hand, she had a very positive social self-construct. She was very popular and knew and liked her position in the class. She liked to communicate, to act and to be the centre of attention. Her career aspiration was to become an actress. The class selected her as a class spokeswoman.

Lesson description. The lesson description is given only as a summary, as it would be difficult to understand what happened in a more detailed narrative transcript or even the chronological reconstructed 'ideas'-list without viewing the video tape. For the more important sequences a translation of the transcript is included. To identify interest-oriented actions we normally have to follow a sequence of learning activities, because time is needed for the development of an interest-oriented action.

In the 4th lesson on 'Water and Current' the students were asked to construct four different water circuits (Figure 3). Each task contained questions centred around the observation of the double water column and the velocity of the flow watchers. These flow watchers correspond with the bulbs in an electric circuit. The velocity is similar to the brightness of the bulbs. In the previous lessons the students were introduced to the functioning of the materials used in this series of experiments.

The following description focuses on Nadine and Corinna:

After a short theoretical introduction summarising the results of the previous lesson, the students started the *first experiment.* Nadine went to get the material for her group and a bucket of water to fill the double water column. When she returned to the table two other students were there and asked whether they could join the group. Corinna immediately agreed without asking the other group members. Nadine was not enthusiastic about this, but did not complain, and retired herself from the group. She stood aside and only watched the activities of the others. The two new girls worked on the ***1st water circuit*** (Scene 1) together with Carolin and Corinna. Corinna seemed not to notice that Nadine took no further part in the group activities. She behaved as she did in previous lessons. She was very active during the construction of the circuits and talked a great deal. Her comments mostly concerned her construction activities. The teacher came to the table and asked the two new girls to leave the table. They were told to carry out their own experiment because five group members were too many. The girls left and Nadine returned to the table. The circuit (Scene 1) was ready. The students observed how the velocity of the flow watcher changed when the pump of the double water column was switched off. The students were asked to formulate a conditional statement "the more ..the ...". Corinna turned to the blackboard and carefully read the task. She was not sure how they should carry out the first experiment, especially as to what they should observe. She switched off the double water column as was mentioned in the task. She then formulated her observation.

NA: What shall we do now?

CA: We should watch what happens now.

CO: The flow watcher is rotating ... and column A gets lower until column B is filled up to the same level ...

NA: Yes, but the flow watcher rotates slower and slower.

CO: That depends on where you put it ... in which position (she takes the flow watcher and changes the position on the table).

NA: No ... leave it where it is. ... the more the water level is balanced, the slower the flow watcher is rotating.

Corinna turned to the neighbouring table and started talking. In her opinion the task was done. Nadine and Caroline started to discuss how the observation should be written up. Corinna turned back to her group and formulated the sentence again, which had already been stated by Nadine. The teacher came to the table and discussed the observations with the students. Nadine did not take part in this discussion. It was Corinna who responded and answered the teacher's questions on the behavior of the flow watcher. The teacher confirmed the observations. Nadine had followed the discussion attentively and confirmed her observations of the relationship between the different water levels in the double water column and the velocity of the flow watcher. She was the first out of her group who noticed the relationship during the experiment.

Corinna started the construction of the ***2nd water circuit*** (Scene 2). Nadine now became more involved in the construction. Right at the beginning she wanted to modify and improve the setting by including a tap instead of a clamp. Nadine tried to explain to her group that a tap and clamp serve the same function. In addition, the tap was easier to both install and handle. However, the circuit was constructed with the clamp. Corinna insisted on the clamp because it would be more fun and it was mentioned in the task. The students started up the circuit. They planned to close the tube by screwing up the clamp because they were asked to describe their observation when removing the clamp, but the instructions made no sense to them. Corinna was occupied with fixing the clamp and switched the double water column on and off. Nadine called the teacher for help. After discussing the experiment, for example when the pump should be switched on and off, the students carried out the experiment and discussed their observations. The teacher returned to the table and gave advice on carefully observing the heights of the water levels in the double water column and to listen to the sound of the pump. (In the case of a shortcut, the water level difference slowed down, the pump worked to its maximum level [permanently], but could not maintain the original water level difference. When the clamp was nearly closed, the pump started acting only from time to time -to re-establish the original water level difference thus pumping back the water that had flowed through the circuit.) Nadine was more active during this discussion with the teacher. After the teacher had left the table the students discussed their observations again, especially what Caroline should write down. Caroline started to record in her book the observations they had made. Corinna was sure the observations Caroline had noted were correct and also wrote them down. Nadine disagreed. She started to discuss the result of the experiment again with Corinna. During this talk Corinna maintained that the pump of the double water column had to work harder when the clamp was closed. Nadine repeated the experiment again. This time, however, she used the tap instead of the clamp.

CO: When you close it and not when you open it the pump has to work ... because there is so much water dammed up.

NA: We will repeat it ... but without that stupid clamp.

She switched on the double water column. She closed the tap carefully and observed the water levels in the two columns of the double water column. Her observation differed from the results maintained by Corinna. She tried to convince her classmate, but with no success.

Nadine still had doubts but could not give a reasonable argument to change Corinna's mind and so finished the discussion with the words: "we *will see later when we discuss the observation with the whole class.*"

The three students started to build the ***3rd water circuit*** (Scene 3), a series circuit with three flow watchers. Two of them could be shortcut by opening a tap. So the circuit could be varied from a circuit which included only one flow watcher to a circuit with two or three flow watchers. Nadine was quite active during the construction of this circuit and gave orders to her group members: (to CO) "*... there, you have to use a very short tube*" and so she controlled the construction process and several times compared the developing water circuit on the table with the diagram displayed on the overhead.

CA: What are you doing Nadine? ... we have already two flow watchers.

NA: Yes ... but we need three flow watchers. ... we have to check the circuit first before we start the real experiment.

Corinna and Carolin worked on the setting up of the circuit, but Corinna especially talked a great deal (private talk included) which was normal for her during the construction of circuits. Nadine was much quieter when working. They started to put the circuit into operation. The first task was to have only one flow watcher in the circuit. The three girls were not sure how they could prevent the other two flow watchers from entering the circle. They constructed the circuit correctly, including the two taps which could be used to short-cut two flow watchers. However, they did not see this particular function of the taps. It was Nadine again who asked and discussed the problem of how they could carry out the experiment. Corinna answered her questions but referred to the written task and used the written text. Nadine carefully inspected the circuit and constructed the right idea concerning the function of the taps. The third student Caroline did not take part in this discussion. She was occupied with removing the air bubbles from the tubes. Nadine then closed and opened the taps.

NA: We should start with only one rotating flow watcher ... but I don't know how we should do this.

CO: Yes ... how should we vary the circuit.

NA: Exactly.

CO: (She reads the task again) ... open and close ... okay we should close two first.

NA: Yes but if we

CO: Only that one should be in series ... it can only be this flow watcher (she shows the flow watcher without a short-cut).

CA: (She removes the air bubbles from the tubes)

NA: If we close this tap now (she closes the first tap).

CA: No, leave it open, we must remove the air bubbles first.

NA: Yes ... now only this flow watcher turns.

CO: Yes, but this one is still turning (she points to the flow watcher with no short-cut) ... we must stop, close this one.

CA: (She is still occupied with the air bubbles).

NA: This might have something to do with this branch here.

CO: But we built it exactly like the circuit-diagram.

CO: Perhaps we didn't have enough switches (she points to the taps) ... ...no we have two.

CA: So, all air bubbles must be out of the tubes.

CO: Okay, what shall we do now?

CA: We could ask the teacher.

Nadine, in a sudden state of excitement, tipped her head with her hand. She had discovered the function of the taps. She showed her discovery to her group.

NA: Hey ... if this tap is open, the flow watcher doesn't turn ... because the water prefers this tube where there isn't a flow watcher ... if we close this tap then the flow watcher must turn (she closes the tap) ... look.

CO: (She looks at the flow watchers) now two are circling ... but we need only one that circles.

NA: Only one ... sure (she opens the second tap and both flow watchers are short-cut).

CO: Yes, O.K., we will do it like this (she turns to the blackboard and reads)... we should observe the velocity.... (she turns back to the table and looks at her watch).

The students repeated the experiment and later discussed their observations on the velocity of the flow watchers with their teacher. The more flow watchers in a series circuit the slower the velocity. However, they recorded them all with the same velocity. Nadine was very active in this discussion. She also made sure that the observation, her observation, was noted carefully.

Corinna was not really involved in the problem solving. She started to feel bored. In the end she even looked at her watch to check how many minutes remained before the end of the lesson. Nadine had become more deeply involved in the experiment and tried to determine the real function of the circuit. But at that moment Corinna seemed to be no longer interested in the experiment. She did not feel any joy or excitement, as Nadine did, even though she understood the function of the circuit.

In the discussion with the teacher when she came to the table Corinna took part but not as in previous discussions. Nadine was more active. Caroline wrote down the observations. Nadine did the dictating. Corinna asked the others to sing with her. She started to sing sometimes while the group were constructing the circuits. Often when she felt bored. She tried to have fun and therefore tried to model the situation so that her needs could be fulfilled. In the end comments were made which really demonstrated that she was looking forward to the end of the lesson.

The ***4th water circuit*** (Scene 4) was a parallel circuit including two flow watchers. Again the velocity of the flow watchers was to be observed. Nadine started to build the circuit alone. Corinna preferred to talk privately with students from the neighbouring tables. Caroline was occupied with writing the task into her notebook. But after finishing she joined Nadine to help her construct the circuit. Corinna returned to the table and watched the activities of the others. When the circuit was finished Nadine carefully inspected the construction. She opened and closed the taps and observed the velocity of the flow watchers. Corinna also watched how the flow watchers circled. However, her observations were not correct. Nadine corrected them.

> *CO: I thought that the two flow watchers would circle slower.*
> *NA: No that is not right ... if they are parallel they have the same velocity.*
> *CO: ... If you close this tap (she closes the tap) ... the flow watcher is slower.*
> *Na: No, this is not true... both have the same velocity ...*

The teacher came to the table and confirmed Nadine's observations. She asked some questions concerning the experiment, e.g., how much water was running through different parts of the circuit. Nadine mainly answered these questions. Corinna and Caroline did not participate in this discussion. They started to arrange their things so that they could leave the classroom immediately when the bell rang.

Data interpretation

The following data interpretation is a summary of the results received from a detailed analysis of the verbal and nonverbal student interactions. As described before, we first try to identify interest-oriented actions by the students. The analysis of the activation source of these actions can be used to get a first idea of the composition of the working-self.

Nadine. Nadine, the student with the positive physics self-construct, behaves in a very reserved way at the beginning of the scene described. Her group starts to work on the experimental task but she doesn't participate although she has interest in physics and knows her capabilities in this field. Through the analysis of her reconstructed 'ideas' according to the characteristics given in Table 1, we can identify her interest-oriented actions. Nadine carried out an interest-oriented action, which started during the construction of the 3rd circuit. She experienced a cognitive challenge when trying to find a solution to task 3 and realised a remarkable gain in competence when she found the solution (short-cutting two flow-watchers so that only one, instead of three were circling). This cognitive stabilisation (a) was accompanied by a positive emotional situation (b). Nadine was involved in the group activities, she felt accepted, the others agreed with her explanations and plans, and she could follow her ideas, which were accompanied by feelings of self-determination. She was satisfied with her solution, she was right and enjoyed feeling competent. The personal value (c) lay in the possibility of doing physics her way, which meant self-intentionality in the activities of Scene 3. The positive energy which came with the success in Scene 3 inspired Nadine to organise the task in Scene 4, so here too she was involved in an interest-oriented action. She led the group through the experiment and all of the characteristics mentioned in Scene 3 could also be identified here. In Scenes 1 and 2 Nadine was task-oriented but did not perform an interest-oriented action. Her social situation did not allow her too many positive feelings. In the first scene she felt excluded from the group's communication process and excluded herself instead of trying to integrate. The negative social self-construct was dominant in the working self. She showed her physics competence but Corinna dominated the group and the talks with the teacher. Nadine tried to fit her ideas to the activities of the group and not to be excluded, so there was no self-intentionality in her actions. In the second scene Nadine tried to realise her ideas (using a tube), so elements of the physics self-construct were active at that moment. She wanted to solve the task in an easier way, but Corinna would not accept it. So Nadine withdrew from the group activities again, but did not lose her task orientation. She asked the teacher for help in order to carry out the task correctly, after they had failed to find a solution during their group discussions. This was not important to Corinna, but Nadine wanted to understand what she had done and learn how to carry out the experiment correctly. During this part of the lesson a change from a dominant negative social self-construct (one of the reasons for her passivity), to a dominant positive physics self-construct was observed (Figure 3).

Corinna. Corinna's actions are also reconstructed through 'ideas' and the resulting list is analysed. At the moment when Nadine engaged in an interest-oriented action, Corinna finished hers. She looked forward to the end of the lesson, she began singing and talked to other girls. Her working self was dominated by social self-constructs. Corinna lost her interest in the water circuits because she could not find interesting questions to guide her observations and did not see the relevance of finding rules or solving cognitive physics problems. She was dependent on the instructions of the task and followed them willingly. She discussed the observations of the group with the teacher and was eager to know the right answers and write down the results, but this was motivated by the wish to be a good student.

In Scene 1 and 2 Corinna was engaged in interest-oriented actions. Her interest resulted from the interestingness of the situation, from the experimental materials on the one hand, and from the possibility of private and task-oriented communication on the other. Regarding her emotional situation (b), she enjoyed the manual activity whilst constructing the water circuits, she felt competence at being able to construct the circuits as indicated in the diagrams. Her cognitive stabilisation (a) lay in the lower level, although intellectually she had no difficulty in understanding the implications drawn from the experiments. She felt stimulated and slightly thrilled (b), also because the water circuit was probably open somewhere so that water ran out making everything wet. There were communication activities that were funny. The construction activities also allowed her to talk, chat, laugh and sing (b). She developed a broad variety in her modes of communication and improved them steadily (a). She felt satisfied at being the centre of a communicating group and being its representative when talking to the teacher (b). Communication held a high value (c) for Corinna and her communication activities were self-intentional, because she could choose her partner and the subject of discussion: Corinna was engaged in an interest-oriented action. When the group work became more physics-based task work, she diverted her interest and activities to other issues, such as talking to the neighbouring table, or writing down the results. She did not become engaged in problem solving. She just wanted to do something, but when a question was not too clear it became of no importance to her. She would ask the teacher or just wait until the results were presented to the class. That was sufficient for her. She did not feel the need to find the result for herself.

Conclusion

This article began with a brief review of the major theoretical features of the relationship between learning, self-concept, interests and students' actions. We concentrated on presenting interest as an element of the physics-related self-construct. But our research showed also that other self-constructs, like the social self-construct, are important for students' actions in a classroom context. Based on the theory of Krapp we demonstrated that it was possible to identify interest-oriented actions from classroom observations through reconstructed 'ideas'. These actions are useful to analyse self-constructs active in the working self. With this method it was also possible to show the different compositions of the working self in a number of situations. In the case of Nadine, a change was recorded from a dominant active negative social self-construct to a dominant active positive physics self-construct in the working self. We could determine the activation sources for particular actions, and therefore also for the activation of the different self-constructs.

In the case of Corinna a lack of special interest in physics seemed not to prevent her from demonstrating interest-oriented actions. However, her interest-actions were activated through the 'interestingness' of the environment. Her extremely positive social self-construct determined her actions during group-work phases in physics lessons. Whether frequent interest-oriented actions lead to an increased interest in physics as a personal disposition, and therefore to a new element of the physics-related self-construct, is an open question. This will be pursued in further research. We also continue our investigations with the intention of observing a difference in the learning processes dependent on the activation source of an interested-oriented action: personal interest or 'interestingness'.

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