Widodo, A. (2003). Constructivist learning environments: How do physics lessons in two German's states look like? in D. Krnel (Ed.). *Proceedings of the Sixth ESERA (European Science Education Research Association) Summer-school*. Ljubljana: Faculty of Education, University of Ljubjana, 263-270.

Constructivist learning environments: How do physics lessons in two German's states look like?

Ari Widodo (Widodo@ipn.uni-kiel.de)
IPN – Leibniz Institute for Science Education at the University of Kiel, Germany

Abstract
The study presented here aims at investigating physics teachers' subjective theories of teaching and learning on the one hand, and their teaching practice on the other. It is embedded within a larger project on investigating physics instruction in German schools. The main data source is videos of lessons on "Introduction into the electric circuits" and "Introduction into the force concepts" taught by fourteen teachers from two German's states. Teachers' views of teaching and learning are documented by interviews. Analyses of the literature have resulted in categories on "Constructivist Oriented Science Classrooms" (COSC) used to analyse the videos of the lessons. Analyses of the videos reveal that lessons show only limited characteristics of constructivist learning environments.

Background
The study presented is a part of a larger video study[1] (www.ipn.uni-kiel.de/projekte/video/videostu.htm) that aims at investigating physics teachers' and students' scripts of physics instruction. The project is part of the priority program *"BIQUA* - The Quality of School: Studying Students' Learning in Math and Science and Their Cross-Curricular Competencies Depending on In-School and Out-of-School Contexts" (http://www.ipn.uni-Kiel.de/projekte/biqua/biqua_eng.htm) sponsored by the German Science Foundation that includes a total of 23 projects.

Data for this study is gathered from 14 grade 7 and 8 classes from two German states. Ten of the teachers teach in the highest level (*Gymnasium*) and the other four in the middle level (*Realschule*) of the German three-level school system. All teachers are also engaged in a quality development program in Germany. Hence, we have a special sample of teachers participating in a program that provides access to other information for improving science teaching and learning. Three lessons from two topics ("Introduction into the Electric Circuit" and "Introduction into the Force Concept") were video-documented.

Constructivist principles on teaching and learning provide the theoretical frameworks for this study (Driver, 1989; Duit & Treagust, 1998; Matthews, 1998; Phillips, 2000; Tobin, 1993). The constructivist literature suggests at least six principles related to teaching and learning: (1) Learners have developed pre-conceptions prior to formal schooling; (2) Learners are active constructors of knowledge and learning is an active process of constructing new knowledge based on the existing knowledge; (3) Learning experience should generate perturbation to the learners; (4) Learning is a change in the learners' conceptions; (5) The process of knowledge construction is embedded within a particular social and material context; and (6) Learners are purposive and ultimately responsible for their own learning. These principles and attempts to identify constructivist learning environments, i.e. the Constructivist Learning Environment Scale

[1] The team of the larger project comprises: M. Prenzel, R. Duit, M. Euler, H. Geiser, L. Hoffmann, M. Lehrke, L. Meyer, C. Müller, R. Rimmele, T. Seidel, M. Tesch, I. M. Dalehefte and A. Widodo.

Widodo, A. (2003). Constructivist learning environments: How do physics lessons in two German's states look like? in D. Krnel (Ed.). *Proceedings of the Sixth ESERA (European Science Education Research Association) Summer-school*. Ljubljana: Faculty of Education, University of Ljubjana, 263-270.

(Fraser, 1998; Taylor & Fraser, 1991), the Secondary Teacher Analysis Matrix – Science Version (Gallagher & Parker, 1995), and criteria for constructivist learning environments developed by Labudde (2000) and Tenenbaum et al. (2001) provided a base for the development of a set of categories for "Constructivist Oriented Science Classrooms" (COSC). Since constructivism includes views of what knowledge is and how knowledge is acquired (Duschl & Gitomer, 1991), the COSC also includes principles of conceptual change (Schnotz, Vosniadou, & Carretero, 1999; Vosniadou, 2001) and principles of the nature of science (McComas, 1998). The COSC consists of five categories and each is developed further into three to six subcategories. Some subcategorises are divided further (see table 1).

Table 1. Overview of the categories for "Constructivist Oriented Science Classrooms" (COSC)

A. Facilitating knowledge constructions	B. The relevance and the meaningfulness of the learning experience	C. Social interactions	D. Fostering students to be independent learners	E. Science, scientific knowledge, and scientists
1. Making the students aware of the status of their learning within the whole subject. 2. Exploring students' prior knowledge or ideas. 3. Exploring students' ways of thinking. 4. Providing thinking-provoking problems. 5. Addressing students' conceptions in evolutionary ways. 6. Addressing students' conceptions in revolutionary ways.	1. Exploring students' interests, attitudes, and feelings. 2. Addressing students' learning needs. 3. Addressing real-life events, phenomena, or examples. 4. Using resources from everyday life. 5. Discussing applications of the concepts learned.	1. Student - student interactions. a. Simple interactions among the students. b. Students exchange ideas with other students. 2. Student - teacher interactions a. Simple interactions between students and the teacher. b. Students exchange ideas with the teacher. 3. Social organisation of the class. a. Individual b. Group c. Classroom setting.	1. Providing the students with some freedom to organise their own learning. 2. Encouraging the students to re-think their own ideas. 3. Encouraging the students to be self-regulative and reflective. 4. Taking into account students' critical voices.	1. Acknowledging the tentativeness of science. 2. Acknowledging differences in theories or views. 3. The roles of observation and evidence, hypotheses, theories, and laws in science. 4. Acknowledging differences in the ways to do science. 5. Acknowledging the limitations of science explanations.

These categories are described in more detail in the coding manual. Although these categories are interrelated for coding purposes they are treated as completely separate categories. Therefore, a certain behaviour may be coded into one or more categories. In this study the COSC is used as time based categories, which means that the result does not show how many times a particular behaviour occurs during a lesson but in how many of the time slots of the analysis (10 seconds slots in case of the coding system we use) a certain behaviour is observed. Coding results are, therefore, percentages of the duration of the particular behaviour as compared to the duration of the lessons. Inter-coder agreement tests were performed to calculate the reliability of the category system. Two coders (the author and a person who was not involved in the development of the category system) were independently coding a same video. Kappa scores between 0.80 and 1.00 were achieved which mean that there are excellent inter-coder agreements.

Aims

The main aims of the study are:

- To explore teachers' subjective theories of effective teaching and learning, especially their familiarities with constructivism and conceptual change ideas.
- To observe teachers' teaching practice as compared to constructivist principles identified in the literature.

Methodology

Questionnaires, interviews, and video documents were employed to collect data. Videotaping the lessons is certainly the central data collection strategy. Lessons were video-documented using two digital video cameras. One camera was directed to the teacher and the other camera was directed to the class as a whole. This strategy enabled us to pick up interactions between the teacher and the students and the whole class view as well.

At the beginning and at the end of the school year students were given a questionnaire on affective variables like interest and self-concept, on their meta-cognitive views and a test assessing their physics knowledge regarding the two topics. Therefore, it is possible to measure changes in students' interest and achievement over the school year. Moreover, at the end of each lesson, the students were requested to fill in short questionnaires on their mental activities and learning motivation during the lesson. At the beginning of the study, the teachers were given a short questionnaire, mostly on technical issues and on their meta-cognitive views. After documenting the second topic teachers were interviewed on various facets of their views on teaching and learning physics, such as their views on taking into account students' perspectives and students' prior knowledge. These interviews included stimulated recall of parts of their teaching.

The COSC is used as an observational instrument to analyse the videos and as a framework to analyse teachers' interviews. The video analyses software VIDEOGRAPH (Rimmele, 2002) is used to analyse the videos. A combination of quantitative and qualitative methods is employed to analyse the data. Hence the analyses allow to make use of the "rich" data available to provide deeper insight into science teaching and learning.

Results

Data analysis is still in progress. The preliminary results presented here are based on two teachers, LB (from Bavaria) and LS (from Schleswig-Holstein). They are purposely chosen because their students show interesting differences with regard to their achievement and interests. Information on both teachers and the students is summarised in table 2.

Widodo, A. (2003). Constructivist learning environments: How do physics lessons in two German's states look like? in D. Krnel (Ed.). *Proceedings of the Sixth ESERA (European Science Education Research Association) Summer-school*. Ljubljana: Faculty of Education, University of Ljubjana, 263-270.

Table 2. The characteristics of LB and LS

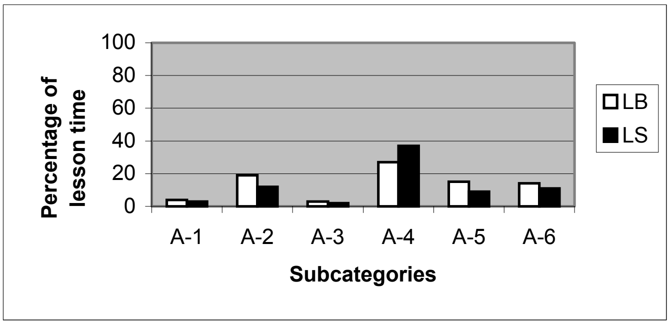
	LB	LS
Type of school	Middle level (*Realschule*)	Highest level (*Gymnasium*)
Students' achievement	Low	High
Development of students' interests	High	Low
Teachers' views as revealed during the interviews		
In general	Fairly well informed about recent developments in science education. Has written a booklet "Educational Cookbook" which displays his familiarity.	Not informed about recent developments in science education regarding teaching and learning science. / Does not fully plan instruction but likes to "improvise".
Major pedagogical concerns	Support and incite students' questioning / Support verbalisation and argumentation / Wishes to be more courageous to try student oriented teaching methods.	Emphasis: needs and interests of students as well as relevance for explaining the everyday world. / What students do (playing or tinkering) is closely linked with the cognitive domain.
Dealing with students' conceptions	Is familiar with key students' pre-instructional conceptions.	Is not familiar with the students' conceptions literature.
View of learning	Is familiar with the basic principles of constructivism.	No elaborate view of learning.
The role of the teacher	No elaborate view.	Moderator who activates students

The results of video analyses using the COSC are presented in the following figures (see figure 1 to figure 4)

a. Facilitating knowledge constructions

The data suggests that both teachers do not show significant differences with regard to this category. Except for subcategory A-4, the other subcategories are observed in only very limited time. Low scores on most subcategories indicate that lessons do not clearly aim at facilitating students' knowledge constructions (see figure 1).

Figure 1. Facilitating knowledge constructions

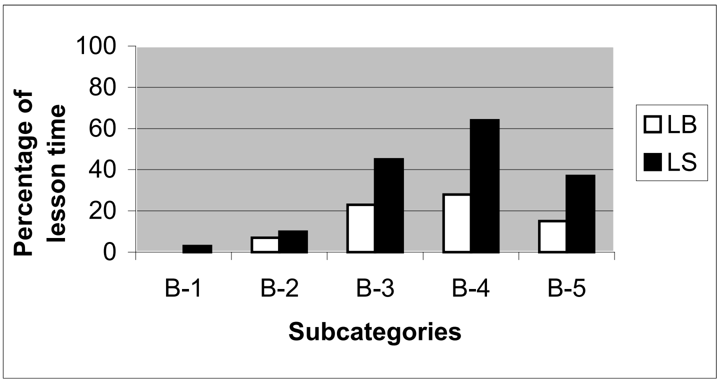


A-1: Making the students aware of the status of their learning.
A-2: Exploring students' prior knowledge or ideas.
A-3: Exploring students' ways of thinking.
A-4: Providing thinking provoking problems.
A-5: Addressing students' conceptions in evolutionary ways.
A-6: Addressing students' conceptions in revolutionary ways.

b. The relevance and the meaningfulness of the learning experience

Here the two teachers show quite different features. Relatively high percentages in B-3, B-4, and B-5 suggest that both teachers made some efforts to link instructions and everyday life. Interestingly, LB's students show rather positive development of interests (see table 2) despite the fact that during the lessons there is no deliberate effort to explore students' interests.

Figure 2. The relevance and the meaningfulness of the learning experience



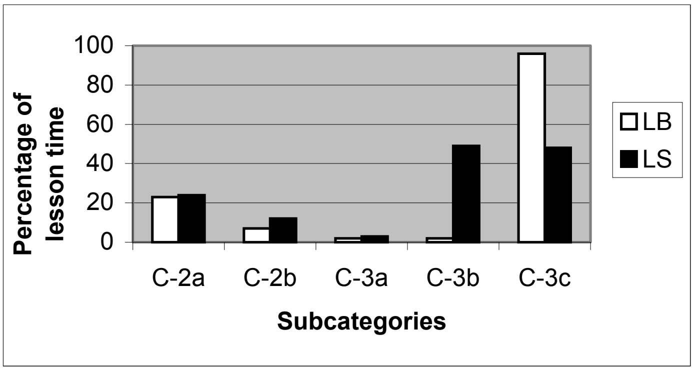
B-1: Exploring students' interests, attitudes, and feelings.
B-2: Addressing students' learning needs.
B-3: Addressing real-life events, phenomena, or examples.
B-4: Using resources from everyday life.
B-5: Discussing applications of the concepts learned.

Low percentages on B-1 and B-2 suggest that students' interest and learning needs are just taken for granted and therefore are not purposively explored during the lessons.

c. Social interactions

Despite our best efforts to understand student-student interactions during group work, they could not be appropriately coded. This is partly due to the complexity of the conversations and partly due to the quality of the voice picked up by the microphones. Therefore, no results on student-student interactions (categories C-1a and C-1b) can be presented here.

Figure 3. Social interactions



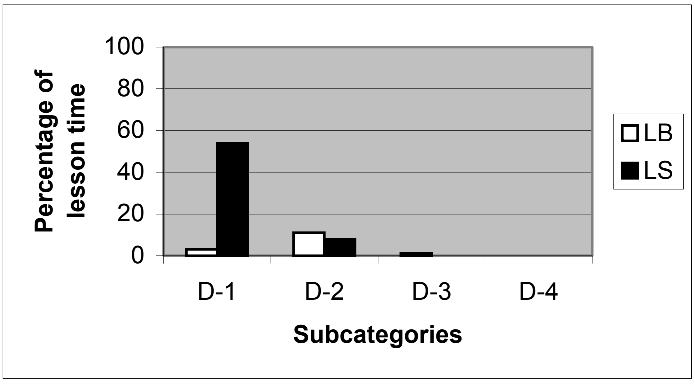
C-2a: Simple interactions between students and the teacher.
C-2b: Students exchange ideas with the teacher.
C-3a: Lessons are organised in individual setting.
C-3b: Lessons are organised in group setting.
C-3c: Lessons are organised in classroom setting.

As figure 3 shows, interactions between the teacher and the students are observed in limited time (slightly more than 20% of the lessons). Moreover, they are usually in form of simple interactions, such as the teacher asks questions and the students answer them, that do not involve any exchange of ideas. This suggests that lessons are dominated by a one-way information direction from the teacher to the students. With regard to the social organisation of the class, both teachers show very different strategies. LB prefers to employ a whole classroom setting, while LS combines a whole classroom setting and group work.

d. Fostering students to be independent learners

Figure 4 shows that there is little effort to foster students' independency in learning. Although LS's students are given some sort of freedom to do the tasks, however, self-regulation and metacognition, which are very important for the development of independency, are never addressed. LB tightly controls the class. As previously mentioned, during the interview LB acknowledges that he is not ready yet to organise his lessons in more "student-oriented" ways. Therefore, it is understandable that he tightly controls his lessons.

Figure 4. Fostering students to be independent learners



D-1: Providing the students with some freedom to organise their own learning.
D-2: Encouraging the students to re-think their own ideas.
D-3: Encouraging the students to be self-regulative and reflective.
D-4: Taking into account students' critical voices.

e. Science, scientific knowledge, and scientists
Both teachers never address issues characterised by the subcategories as shown in table 1. Teachers may consider that such issues should not be introduced already to the students of 7 and 8 grades.

Discussion

The interview reveals that LB is quite well informed about the recent development in science education and is quite familiar with the basic principles of constructivism. However, compared to characteristics of constructivist lessons as identified in table 1, his subjective theory of teaching is not very elaborate, for example: it does not contain aspects of students' interests, students' learning needs and encouragement for the students to be independent learners. Observation of his lessons clearly shows that his lessons reflect his subjective theory, for example: he explores students' prior knowledge and addresses students' conceptions using verbal argumentations, but he tightly controls the lessons. LS's subjective theory of teaching and learning also contain some aspects of constructivist lessons as identified in table 1, such as that students' everyday life provides important context for learning and that the teachers' role is to activate the students. Observation of his teaching shows that he also practices them, such as he links the lessons closely to everyday life and provides the students with some freedom to organise their own learning. In his subjective theory of teaching and his teaching practice, however, other significant aspects of constructivist teaching and learning, such as exploring and addressing students' prior knowledge and encouragement to be self-regulative and critical are missing.

The results from the two teachers' interviews and analyses of their teaching practice using the COSC clearly suggest that teaching practice is affected by teachers' subjective theory of "good teaching and learning". The subcategories observed during the lessons are usually the ones that are identified in teachers' subjective theories. As identified from the interviews, teachers' subjective theories of teaching and learning contain aspects of characteristics of constructivist teaching as described in the COSC to a limited extent. Consequently, only some aspects of constructivist teaching can be observed in the lessons.

In general, our data suggest that physics lessons taught by both teachers meet the criteria of constructivist teaching only to a limited extent. Of course, there are aspects of constructivist lessons observed, however, there are other aspects of constructivist teaching that are not observed during the lessons: students' awareness of the status of the learning, exploration of students' ways of thinking, exploration of students' interests, encouragement to be self-regulative, reflective and critical, and aspects of knowledge generation process. Some other aspects of constructivist teaching are observed in limited extent, such as: exploration of students' prior knowledge, addressing students' prior knowledge and encouragement for the students to re-think their own ideas.

Acknowledgments
The author is a lecturer at the University of Education in Bandung, Indonesia. My PhD study at IPN-Kiel is supported by a grant from the German Academic Exchange Service (DAAD). As mentioned above, the work presented here is part of a larger study. Therefore, there are various contributions of the other colleagues to the work presented here. I am grateful for their support. Finally, I would like to thank the teachers and the students for their participations in our study.

References

Driver, R. (1989). Changing conceptions. in P. Adey, et al. (eds.). *Adolescent Development and School Science*. New York: The Falmer Press.

Duit, R. & Treagust, D.F. (1998). Learning in science - from behaviorism towards social constructivism and beyond. In B. J. Fraser & K. G. Tobin (Eds.), *The International Handbook of Science Education*. Dordrecht: Kluwer Academic Publisher, 3-25.

Duschl, R. A. & Gitomer, D. H. (1991). Epistemological perspectives on conceptual change: Implications for educational practice. *Journal of Research in Science Teaching*, 28(9), 839-858.

Fraser, B. J. (1998). Science learning environments: Assessment, effects and determinants. In B. J. Fraser and K. G. Tobin (eds.). *The International Handbook of Science Education*. Dordrecht: Kluwer Academic Publishers, 527-564.

Gallagher, J. & Parker, J. (1995.) Secondary teaching analysis matrix (STAM) – Science version, Occasional Paper, Michigan State University.

Labudde, P. (2000). *Konstruktivismus im Physikunterricht der Sekundarstufe II [Constructivism in upper secondary physics instruction]*. Bern, Switzerland: Paul Haupt Verlag.

Matthews, M. R. (ed.) (1998). *Constructivism in Education: A Philosophical Examination*. Dordrecht: Kluwer Academic Publishers.

McComas, W. F. (ed.) (1998). *The Nature of Science in Science Education Rationales and Strategies.* Dordrecht: Kluwer Academic Publishers.

Phillips, D. (2000). *Constructivism in Education: Opinions and Second Opinions on Controversial Issues*. Chicago: The University of Chicago Press.

Rimmele, R. (2002). *The Videograph*. Kiel, Germany: Leibniz Institut for Science Education (http://www.ipn.uni-kiel.de/aktuell/videograph/htmStart.htm)

Schnotz, W., Vosniadou, S., & Carretero, M. (1999). *New Perspectives on Conceptual Change*. Amsterdam: Pergamon.

Taylor, P. C. & Fraser, B. J. (1991, April). CLES: An instrument for assessing constructivist learning environments. Paper presented at the Annual meeting of the National Association for Research in Science Teaching (NARST), The Abbey, Fontane, Wisconsin.

Tenenbaum, G. et al. (2001). Constructivist pedagogy in conventional on-campus and distance learning practice: An exploratory investigation. *Learning and Instruction 11*, 87-111.

Tobin, K. (ed.) (1993). *The Practice of Constructivism in Science Education*. Washington DC: AAAS Press.

Vosniadou, S. (2001). How Children Learn. Educational practices series-7: International Academy of Education (http://www.ibe.unesco.org/publications).