Talking about physics during labwork activities
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Abstract. Verbalisations of physics knowledge while experimenting are an intended and important step towards physics learning in labwork situations. Different labwork sessions have been analysed using a "category-based analysis of videotapes (CBAV)" method. The aim was to find relations between characteristic contexts of labwork and students' verbalisation of basic physics concepts. Two grids of categories, one for contexts of labwork and the other for verbalisation of different kinds of knowledge, were used. Relations between the two types of categories were calculated. The results show that university students doing experiments in the field of electrodynamics seldom verbalise their knowledge (about 16% of lab time). Up to 80% of the lab time is used for the two main categories, "manipulating apparatus" and "doing measurements". Taking into account that the density of students verbalisations within these two categories is low, implications for improving labwork might be (1) reducing the time required for making measurements, and (2) combining doing measurements with making predictions or doing rough calculations.

Subject/Problem. Within the framework of a constructivist learning theory (Fischer & von Aufschnaiter 1993; Roth & Duit 1997; Driver 1988), we think that effective learning takes place in student-centred teaching/learning situations, like labwork situations, which encourage students to make their own observations. Verbalisations of physics knowledge are an intended and important step towards physics learning (Howe, 1996), and learning in terms of linking theory to practice is considered as a major objective of labwork (Lunetta 1997; Boud 1986; Welzel et al. 1997). But some researchers (Toothacker 1983; Woolnough 1983) have raised issues regarding the effectiveness of labwork in relation to this objective. With these issues in mind our main research questions are:

• How much time during lab work is devoted to activities in the different kinds of contexts?
• How much time during labwork is devoted to verbalising different kinds of knowledge?
• Which of the contexts promote best students to talk about physics?

Design. We designed seven relevant categories for contexts of labwork, mainly defined by the different resources used, such as apparatus or labguide; and four categories for verbalisation of different kinds of knowledge, such as technical or physics knowledge. In this way the students' activities, in different labwork contexts, and their verbalisation, can be analysed together almost in real time. In previous studies (Kyle et al. 1979, Okebukola 1985) the activities of students during labwork were analysed using the Science Laboratory Interaction Category (SLIC) method. The categories for the contexts are quite similar in SLIC and CBAV, e.g. manipulating apparatus and recording data are used in the same way. But with the SLIC Method it is not possible to investigate the use of physics concepts during labwork. Therefore we developed the second grid of categories referring to students' verbalisations of physics knowledge. Stein et al.(1990) structured a labwork session in three successive phases and categorised verbal statements of students during each of
these phases. These categories correspond to the categories of the CBAV method. The reliability of the CBAV method was checked. With a 85% level of agreement for one coder repeatedly analysing videos one can consider the results as trustworthy. For more information see Niedderer et al. (1998).

Procedure. Data was gathered at the University of Bremen during the winter term 1996/97. Students performing three different labwork sessions were videotaped. The course was designed for physics majors studying physics in the second year, and was in the content area of electrodynamics. All the experiments were carried out by students in groups of two as is traditional in German universities. At the beginning of an experiment the apparatus was more or less already set up. In the three labwork sessions students had to observe and determine physics quantities and relations between them. In the first experiment students had to verify a standard law (Coulomb's law). In the second the students were supposed to measure the temperature dependence of two resistors. And in the last labwork session investigated, the students were supposed to gain familiarity with filter circuits. Several videorecordings of different groups of students doing the three experiments were analysed using the CBAV method.

Data analysis. While watching the videotaped labwork sessions, every 30 seconds the coder categorises both the activity in a labwork context and the verbalisation. Using videorecordings offers the chance to look at some situations, such as complex conversations, two or three times. The 30 seconds units detected in each category were added and the mean values were determined over the labwork sessions analysed. For analysing relations between the two types of categories, a "density" was calculated. The ratio of the number of time units coded in knowledge category X divided by the total number of time units in this labwork context category Y (multiplied by 100), we called the "density" of knowledge X in category Y.

Findings. Labwork activities: Our data show that the commonest activities in the labwork sessions investigated are "manipulating apparatus" (37% of lab time) and "doing measurements" (36% of lab time). With an average of 12% of the whole lab time, the category "labguide" is the third most often used labwork context in our labwork sessions. The categories "calculator" and "paper and pencil" are used for only a very limited amount of time (4% of lab time and 1% of lab time), reflecting the fact that students seldom analyse their data during the labwork sessions.

Verbalisation of knowledge: During the labwork sessions analysed, the students do not verbalise their knowledge very frequently (average knowledge verbalisations are 16% of lab time). The time used for statements about physics and technical issues are nearly the same (7% of lab time and 5% of lab time). Statements about mathematical knowledge were only detected very occasionally (3% of lab time). This shows that data analysis is not an important part of the labwork session, confirming the findings of the previous section about the use of the categories "pen and pencil" and "calculator"

Relations between activities and verbalisation of knowledge: From the density analysis, there is no indication that more time used for doing manipulation contributes to more statements about knowledge. In the case of technical knowledge it seems to be rather the opposite. The densities of physics statements in the category "labguide" is different in the three labwork sessions, which can be interpreted as the influence of the labguide on verbalisations.
**General interest.** Implications of our results might be: (1) to reduce the time for measurements, (2) to link doing measurements with making predictions or theoretical analysis of the data, (3) to ask questions by the tutor or in the labguide during the process of doing measurements, and (4) to include analysis of data and rough calculations in the measurement process.

**References.**


