

RESULTS OF THE EMPIRICAL STUDY

Quantitative Data Analysis

OVERVIEW

This chapter is concerned with presenting the quantitative results of the empirical study. All choices in connection with the data analysis are thoroughly explained, followed by explicitly displaying the results. The quantitative data is reduced by means of *factor analysis*. Presenting the findings includes determining the number of factors that are relevant in the context of mathematics teacher professional development, reporting about the empirical dimensions of teachers' needs, their internal consistency, teachers' answering behavior within those dimensions, and the relations between them. Finally, the presentation of the quantitative results concludes with some remarks and reflections on this methodological approach and the corresponding relevance of the results.

QUANTITATIVE DATA ANALYSIS AND RESULTS

The quantitative data has been analyzed by exploratory factor analysis since the goal was to explore the field of mathematics teacher professional development and to discover the main dimensions relevant from a teacher's perspective. As chapters one and two indicate, this research area is a highly complex theoretical field that necessitates generalization. At least partly, factor analysis yields simplification and reduces interlacement by indicating what the important and main variables are. The aim of the quantitative approach is to display interrelationships among variables that operationalize different aspects of teacher professional development as an aid in further conceptualizing this construct. Several facets included in the items are reduced to a few dimensions, which then are analyzed in detail. Additionally, relationships among dimensions are unraveled. As method, principal component analysis has been applied. Since the expected dimensions are supposed to be uncorrelated, orthogonal rotation was chosen. In the following, methodological decisions going beyond common practice of factor analysis are thoroughly substantiated.

Determining the Number of Factors

Since the conducted factor analysis was concerned with exploration rather than hypothesis testing, factors have not been extracted to a predesignated number. In contrast, several factor solutions were carefully tested. A perfect reproduction of the data can definitely be obtained by extracting enough factors. Nevertheless, the task and

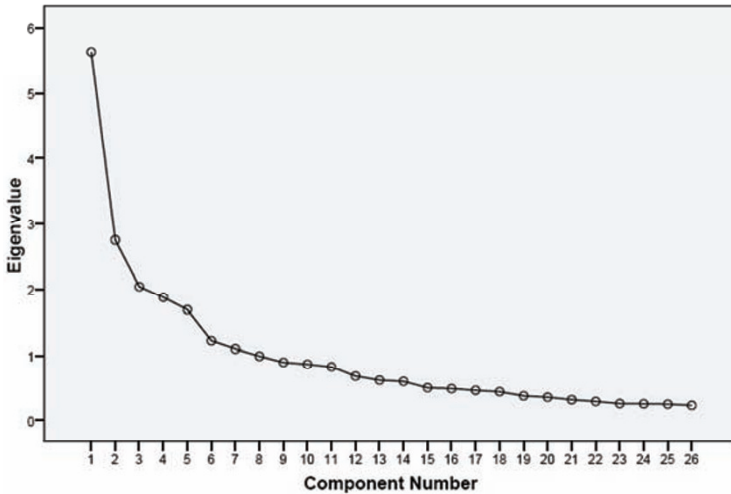


Figure 11. Scree plot.

challenge is to uncover a limited number of factors representing an adequate amount of the original information (Gorsuch, 1983). As a first guess, an arbitrary number of factors was extracted and principal component analysis led to seven eigenvalues greater than one. The scree test (figure 11) suggested the extraction of five or six factors (Kline, 1994).

In accordance with the results of the scree test, a six-factor and five-factor solution was tested. Ultimately, the decision how many factors are to retain was based on the following criteria:

- Each factor should contain enough items with high loading.
- Internal consistency estimated by Cronbach's alpha has to be sufficiently high.
- A factor must account for a suitably high amount of variance.
- The factors should be homogenous and meaningful regarding content.

As best fit for the data, item loadings above .30 with no or few crossloadings and a minimum of two items per factor were considered. Since in the six-factor solution, the fifth factor only comprised two items and the sixth one possessed weak Cronbach's alpha (.49), the five-factor solution was favored. In the five-factor model, reliability was satisfactory with coefficients between .67 and .83. Varimax rotation of the factors was an efficient way of obtaining simple structure. In four cases, items also loaded on another factor. However, these side loadings were moderate as they were located in the range from .33 to .43. Percentage of variance accounted for by the five factors is presented in table four.

The first factor accounts for 22% of variance, the factors 2 to 5 for values between 11% and 6%. When additionally extracting a sixth factor, the contribution is lower than 5.0%. The five factors are homogenous with regard to content and consequently suitable to interpret; the interpretation will be elaborated on in the next section. Summarized, the best fit to the data is obtained by accepting a 5-factor solution.

Table 4. Total variance explained

<i>Component</i>	<i>Extraction sums of squared loadings</i>		
	<i>Total</i>	<i>% of variance</i>	<i>Cumulative %</i>
1	5.633	21.666	21.666
2	2.754	10.592	32.259
3	2.043	7.856	40.115
4	1.876	7.214	47.329
5	1.687	6.488	53.816

Empirical Dimensions of Teachers' Needs

The part of the questionnaire relevant in the context of this work consisted of 26 items. Factor analysis led to five dimensions describing relevant issues of teachers' view on their professional development. In what follows, items and loadings for each dimension are presented and information about naming and interpreting the factors is given. All factors possess salient loadings, contributed by variables that are mostly loading only this factor up. Factors are interpreted according to the highest loading variables. A meaningful label displays the summary of the interpretation. Items and loadings for the first factor are shown in [table five](#):

Table 5. Items and loadings of the first factor

<i>Factor 1</i>	<i>Loadings</i>
In the subject department of my school, general principles of teaching are arranged.	.778
In the subject department of my school, agreements about schedules and topics are made.	.759
Materials delivered during in-service training courses are distributed in the subject department of my school.	.742
In the subject department of my school, principles and criteria of assessing students in mathematics are agreed.	.723
Contents of in-service training courses are reported to colleagues.	.697
Professional exchange with colleagues of my school based on school internal in-service training is fruitful.	.475

Factor 1 comprises six items of which only the last one has a low side loading of .331 on the third factor. Content analysis reveals that the high loading items are concerned with issues of teachers' subject affiliation and departmental organization at their own school. Particularly, the relevance of collegial and shared work in the subject department is stressed. This collaborative work comprises agreements about general principles of subject matter teaching, schedules, topics, assessment, and access to resources provided by in-service training. Hence, the factor is labeled, *Importance of the subject department*.

In [table six](#), items and loadings for the second factor are listed:

Table 6. Items and loadings of the second factor

<i>Factor 2</i>	<i>Loadings</i>
School administration practically supports the transfer of issues imparted at an in-service training to daily practice.	.810
School administration is interested in bringing issues imparted at an in-service training into daily practice.	.761
School administration honors attending in-service training courses by different measures.	.713
My school administration supports me in my endeavor to attend an in-service training course.	.711
School administration checks for changes in classroom practice after attending an in-service training course.	.679
Supervisory school authority supports me in my endeavor to attend an in-service training course.	.549

In the second factor, no items have any side loadings. The factor refers to support by the school administration, first concerning the implementation of issues imparted by an in-service training, second attending training courses in general and third possible changes as effect of an in-service program. Additionally, the last item mentions support by a superior level, namely supervisory school authority. As regards content, this factor is consequently named, *Support by school policy*.

The following factor consists of seven items and alludes to teachers' needs regarding their professional development:

Table 7. Items and loadings of the third factor

<i>Factor 3</i>	<i>Loadings</i>
I also see necessity of professional development for my colleagues.	.749
I see necessity for myself regarding professional development.	.721
It is important to cooperate with other teachers when implementing results of an in-service training.	.591
While exchanging with other colleagues during an in-service training, I become aware of my own deficits and needs.	.521
Professional exchange with colleagues of other schools is profitable.	.502
A successful in-service training course considers the individual needs of the participants.	.471
I attach importance to attending in-service training events together with colleagues from different school types.	.429

The items of the third factor refer to general needs of teachers concerning professional development. These requirements are not only brought up as a personal issue but primarily as a collaborative one. Cooperation with other teachers is regarded helpful in order to become aware of own deficits, but also profitable to sustain professional exchange. Interestingly, professional development is not simply regarded on the individual level but intertwined with collaborative aspects. One item possesses a moderate side loading: The item *Professional exchange with colleagues of other*

schools is profitable also loads on the fifth factor (.429). Finally, the factor is labeled, *Necessity of professional development*.

Items and loadings of the fourth factor are presented in [table eight](#):

Table 8. Items and loadings of the fourth factor

<i>Factor 4</i>	<i>Loadings</i>
Implementation of issues learned during in-service training is difficult because the content was not sufficiently related to practice.	.777
I experienced that I gave up new ideas and suggestions after a short time and went back to the approved methods.	.736
Suggestions obtained by an in-service training course proved to be impractical afterwards.	.718
Implementation of issues learned during in-service training has turned out to be difficult because my school only slowly prepares for new content.	.563
Implementation of issues learned during in-service training has turned out to be difficult because the colleagues of my subject department at school only hesitantly prepare for new content.	.427

While considering the highest loadings, it is clear that this factor is concerned with the challenge of implementing new ideas and issues learned by in-service training. Teachers very quickly fall back on approved methods and the practicability of new aspects appears questionable sometimes. Besides the focus on individual experiences with transfer into practice, the support by colleagues or the school is mentioned. The last two items have negative side loading on the first factor. The fourth factor is named, *Implementation and practicability*.

Items and loadings of the fifth factor are given in [table nine](#):

Table 9. Items and loadings of the fifth factor

<i>Factor 5</i>	<i>Loadings</i>
The contact to the trainers of the in-service training led to professional exchange.	.777
The contact to colleagues I met at previous in-service training events led to professional exchange.	.736

The fifth factor only contains two items, which stress the relevance of contact and professional exchange to trainers and colleagues after attending an in-service training course. However, the factor covers aspects not yet treated in the other dimensions, but is obviously not optimally operationalized. As factor label is chosen, *Sustained collaboration*.

Each of the five dimensions describes a field of consistent answering behavior towards a homogenous item group. The rationale of specifying factors is to obtain dimensions defined by items and their loadings that account for a particular relationship. These dimensions structure teachers' perception, cognitive representation, and affective assessment towards professional development. All dimensions were interpreted from the content of the items that loaded on them.

Obviously, the first two dimensions are related to context variables since they stress the relevance of colleagues teaching the same subject area and the supportive role of school administration. The third dimension elaborates on the necessity for professional development as both a personal and a community issue. A successful in-service training course considers the individual needs of the participants, actually a trivial demand, but in the reality of professional development, many conflicts arise from that. Within the fourth dimension, the effect of professional development is subject of debate since possible implementation of issues imparted at an in-service training and practicability in general are raised. The fifth and last dimension is concerned with sustained collaboration in terms of professional exchange. In the next two sections, these dimensions are further scrutinized while elaborating on their internal consistency and the frequencies within them.

Internal Consistency of the Dimensions

As the preceding analysis showed, each factor is constituted by items, which almost singly load on it, and is homogenous with regard to content. By factor analysis, items were grouped together according to their correlative coherency. A formal criterion for proving homogeneity is given by Cronbach's alpha. Table ten shows the scales' Cronbach's alpha reliability coefficient for internal consistency:

Table 10. Cronbach's alpha for the factors

<i>Factor</i>	<i>Labeling of the scale</i>	α
1	Importance of the subject department	.834
2	Support by school policy	.834
3	Necessity of professional development	.668
4	Implementation and practicability	.709
5	Sustained collaboration	.818

For the dimensions *Importance of the subject department*, *Support by school policy* and *Sustained collaboration* Cronbach's alpha is good with values higher than .8, for the dimension *Implementation and practicability* it is acceptable while for the dimension *Necessity of professional development* the value is a bit lower than .7. In sum, all Cronbach's alphas are found to be sufficiently high and indicate internal consistency of the dimensions.

The reliabilities for individual statements are under the limit of 0.9 demanded for psychological tests, but in the following, group statements are defined for which only a reliability of 0.7 is needed. Insofar, the reliabilities are good and acceptable for four of the dimensions, and even the third dimension can be considered as being satisfactory as the value is close to .7.

Frequencies within the Dimensions

The identified dimensions structure teachers' attitudes towards and experiences with professional development. However, the conducted analysis so far does not provide any indication about the answering behavior of participants within the dimensions.

Therefore, this section deals with defining appropriate scales. That is, scores for the individuals on the extracted factors were computed. A scale for all dimensions was calculated as follows. For every participant, item responses were simply summed to create a score for the group of items presenting a factor. By linear transformation¹, a common scale for all dimensions was calculated ranging from 0 to 40. The simple sum score scales were not only transformed but stretched and led to similar intervals for each of the dimensions. As an advantage, a constant interval length of 0.75 was attained and therefore central tendency bias could be diminished. An overview on the common scale scores and their meaning is given in [table 11](#):

Table 11. Scales for the dimensions

	Scales score from ($>$) ... to (\leq)	Averaged value in a single item
Agree	00 – 10	1.00 – 1.75
Partly agree	10 – 20	1.75 – 2.50
Partly disagree	20 – 30	2.50 – 3.25
Disagree	30 – 40	3.25 – 4.00

The obtained scales are unweighted. As showed, the salient loadings on the extracted factors are close to each other so that a simple unweighted model was favored. In what follows, the ranking of the participants along the identified dimensions is presented in detail.

Importance of the subject department. The scoring of participants on the first dimension *Importance of the subject department* as well as the corresponding histogram is presented in [figure 12](#):

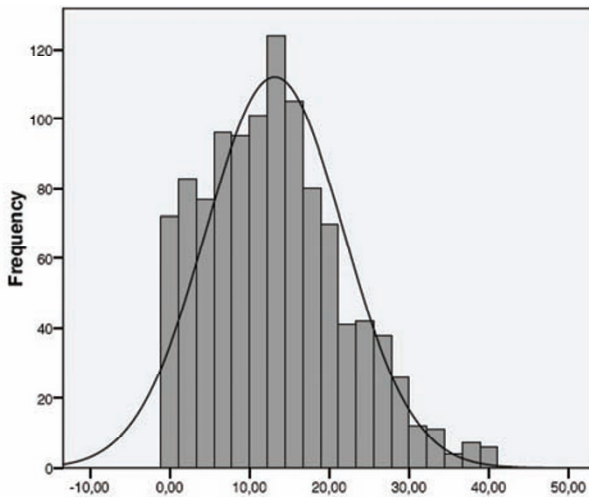


Figure 12. Histogram and table of frequencies of the dimension 'importance of the subject department'. (Continued)

	<i>Scales score from (>) ... to (≤)</i>	<i>Percent</i>
Agree	00 - 10	38.8
Partly agree	10 - 20	44.0
Partly disagree	20 - 30	13.5
Disagree	30 - 40	03.7
	Total	100.0

Figure 12. Histogram and table of frequencies of the dimension 'importance of the subject department'.

The measures of central tendency are located in the range of partial agreement (mean 13.15, std. error of mean .26, median 13.33, mode 13.33), but close to agreement. The data are slightly positively skewed (skewness .56, kurtosis -.04), that is, the higher values disperse stronger; the standard deviation is 8.63.

Nearly 83% of teachers perceive their subject department as a collegial work place where information about professional development and school issues are shared. In total, 18% of teachers do not experience their subject department as relevant and supportive regarding the aforementioned aspects, and among them 4% of participants totally disagree with that view.

Support by school policy. The second dimension is concerned with *Support by school policy*. The scoring of the participants of the study is displayed in figure 13:

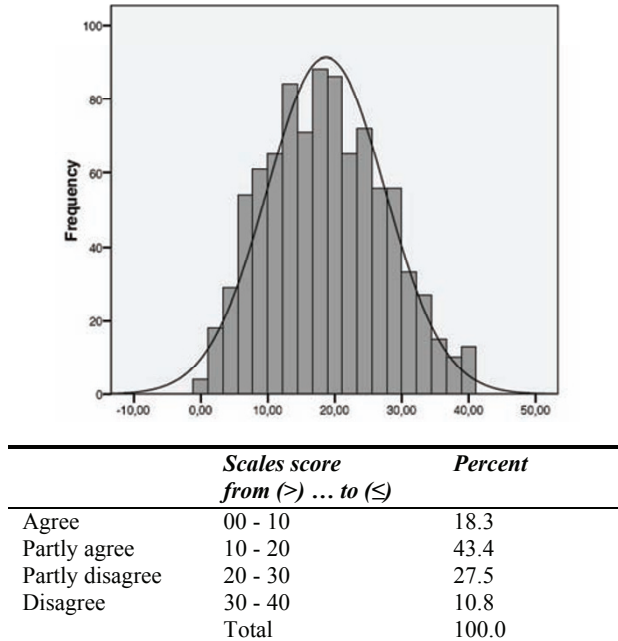


Figure 13. Histogram and table of frequencies of the dimension 'support by school policy'.

The central tendency of the data is located in the range of partial agreement (mean 18.72, std. error of mean .29, median 17.78, mode 17.78), close to partial disagreement. The data are slightly skewed (skewness .21, kurtosis -.58). As the histogram indicates, the variability of the data can be described as follows: dispersion is higher in the range of disagreement while the standard deviation is 8.8.

61% of teachers feel supported by school policy in their endeavor to pursue professional development while 37% of teachers do not. Among the former ones, 18% of teachers are very pleased with the provided support. In contrast, 11% of the teachers are dissatisfied with the help and assistance provided by the persons responsible in their school.

Necessity of professional development. The third dimension is concerned with *Necessity of professional development*. The distribution of data according to the different ranges is shown in [figure 14](#):

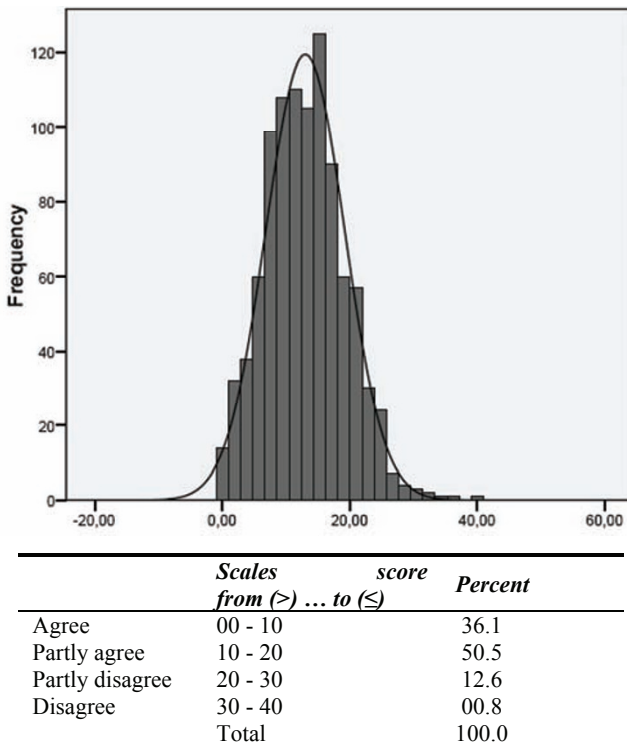


Figure 14. Histogram and table of frequencies of the dimension 'necessity of professional development'.

The center of the distribution is located in the range of partial agreement, close to the one of agreement (mean 13.00, std. error of mean 0.20, median 13.33, mode 15.24).

The standard deviation is rather small (6.18), the distribution of scores extends from the mean further towards the larger values (skewness 0.33), and there is a higher concentration of scores around the mean (kurtosis 0.25).

Individual and general need for professional development is widely stated by almost 87% of teachers, and remarkably, 36% of them fully agree that such support for practicing teachers is required. Only 13% of teachers do not consider need for professional development and only 1% even denied any.

Implementation and practicability. The fourth dimension deals with *Implementation and practicability* of issues imparted by an in-service training. The scoring of the participants is presented in the following figure:

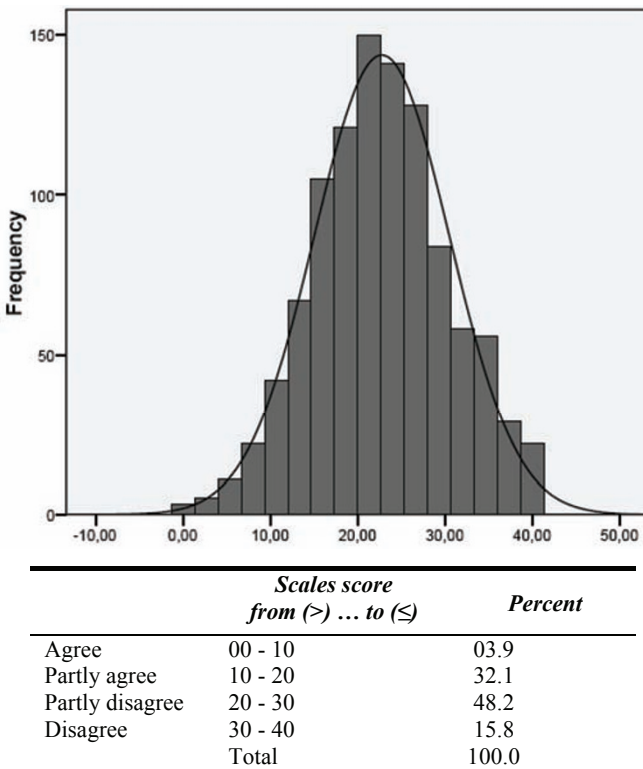


Figure 15. Histogram and table of frequencies of the dimension 'implementation and practicability'.

The center of the data is in the range of partial disagreement (mean, 22.75, std. error of mean .24, median 21.33, mode 21.33), but close to partial agreement. The standard deviation is 7.73 and the distribution is symmetric. A low concentration

of scores around the mean can be stated, that is, the distribution is relatively broad (kurtosis -.21). Contrary to the other scales, the orientation of this dimension is negative.

Not surprisingly, almost 36% of teachers do not assign practicability to issues imparted by an in-service training. They consider the implementation of new issues as difficult. Interestingly, although much research in the field is concerned with effects of professional development events, the majority of teachers (64%) regards the learnt issues as practicable and does not question their implementation.

Sustained collaboration. The fifth and last dimension is concerned with *Sustained collaboration*. The measures of dominant tendency identify the range of partial disagreement as center of the data (mean 25.07, std. error of mean 0.36, median 26.67, mode 40.0). The standard deviation is rather high (12.00), the distribution of scores extends from the mean further towards the smaller values (skewness -.36), and the distribution is relatively narrow (kurtosis .79).

Table 12. Frequencies of the dimension 'sustained collaboration'

	<i>Scales score from (>) ... to (<=)</i>	<i>Percent</i>
Agree	00 – 10	10.0
Partly agree	10 – 20	31.0
Partly disagree	20 – 30	23.5
Disagree	30 – 40	35.5
	Total	100.0

41% of teachers agreed that encounters with colleagues or trainers during an in-service training course led to sustained professional exchange while 59% of teachers did not. Remarkably, only 10% fully agreed to the statement and in contrast, nearly 36% of teachers fully disagreed. That is, experiences of teachers in the field of professional exchange are quite different. Although collaboration among teachers and teacher educators is highly valued in the research literature, the experiences of teachers indicate that in this regard, much development is needed.

To sum up, the different means, medians and standard deviations for all dimensions are presented in [table 13](#):

Table 13. Means, medians and standard deviation for the dimensions

<i>Dimension</i>	<i>Mean</i>	<i>Median</i>	<i>Std. deviation</i>
Importance of the subject department	13.15	13.33	8.63
Support by school policy	18.72	17.78	8.80
Necessity of professional development	13.00	13.33	6.18
Implementation and practicability	22.75	21.33	7.73
Sustained collaboration	25.07	26.67	12.00

However, the means do not provide the detailed information that could be displayed by the previous analysis. The measures of central tendency as well as dispersion differ widely. Further analysis, like exploring mean differences for specific groups, is not provided since the aim was primarily to capture the dimensions relevant for teachers in the field of professional development. The more interesting question is thus to find out about the relationship between the dimensions; this issue will be elaborated on in the following subsection.

Correlations among the Dimensions

The correlations between the dimensions give some information about the global structure of teachers’ attitudes towards and experiences with professional development. The partial correlation coefficients are presented in [table 14](#):

*Table 14. Partial correlation coefficients (**correlation is significant at the 0.01 level (two-tailed))*

	<i>Importance of the subject department</i>	<i>Support by school policy</i>	<i>Necessity of professional development</i>	<i>Implementation and practicability</i>
Importance of the subject department				
Support by school policy	.467**			
Necessity of professional development	.227**	.175**		
Implementation and practicability	-.253**	-.242**	-.003	
Sustained collaboration	.213**	.245**	.275**	-.084**

As expected with respect to the choices made while applying the specific factor analysis model, correlations are not that strong, but significant with one exception. They provide some information about how the dimensions relate to each other. Not surprisingly, a positive relationship can be stated between *Importance of the subject department* and *Support by school policy* since both dimensions strongly attach relevance to the school environment. This relationship is characterized by the strongest correlation. The dimensions *Necessity of professional development* and *Sustained collaboration* also correlate positively with those two. That is, teachers attach importance to the collegial work within the subject department, feel supported by their school policy, identify need for professional development and report about sustained collaborations while actively engaging in professional development.

A negative relationship can be assigned to the dimension *Implementation and practicability* and the ones of *Importance of the subject department* and *Support by school policy*. Those who score highly on the two last-mentioned ones, whereby the scale range is from agree to disagree, have low scores on the dimension *Implementation and practicability*, which is of course negatively oriented. In short, a considerable connection can be stated between the support by colleagues and the school as well, and applying and testing ideas provided by in-service training courses.

CONCLUDING REMARKS

Teachers' views on professional development are structured and include different facets. By means of statistical analysis, five dimensions relevant in this broad context were derived, that yielded the best approximation to teachers' consistent answering behavior. That is, semantically related items were replied to in a similar way. Regarding content and correlative aspects, the obtained dimensions were analyzed in detail. Nevertheless, the questionnaire had determined the scope of the analysis and consequently the initial structure within which the dimensions then constituted themselves. The procedure is hence limited with respect to the contributed information.

As mentioned earlier, statements about dimensionality and content strongly depend on the factor-analytical results and the choices made beforehand. But besides denying a clear objectivism, the results are surely not derived subjectively or randomly as they present the best match of structuring the answering behavior according to content. Since the results of the factor analysis can only clarify a certain percentage of the total variance, it may well be possible that the answers to the individual items depend on additional, specific factors. The following presentation of the qualitative results is hence dedicated to further exploring the dimensionality of teachers' professional development. However, the quantitative findings additionally serve to partly framing the subsequent analysis.

NOTES

¹ The simple sum scores were treated as interval data. The following transformation formula was applied: $((\text{Sum of items within a factor}) \times 10 / (\text{amount of items} - 10)) \times 4/3$.