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ABSTRACT

Instructional metacognition refers both to conceptions of students about the contribution that instructional interventions can make to their learning, and to the impact of these conceptions on students' interpretation and use of instructional interventions. This study analyzes student conceptions of efficiency-related attributes of instructional interventions--instructional elements or features of them, such as lecture, courseware, transparencies during a lecture, cartoons in a textbook; and learning activities (activities both initiated and executed by the student) such as making a summary or discussions with peers. A survey study of university freshman (n=489) was re-analyzed to address these issues. The questionnaire contained identification questions, and a list of 20 instructional interventions and 20 learning activities to be rated on a 5-point Likert-type scale for their contribution to study result and study time. Gender, domain of study, and educational background were analyzed as independent variables. Results include: (1) university freshman largely perceive current school practices of both interventions and learning activities to be highly efficient; (2) students perceive that interventions that contribute to an increase of study results decrease study time, and learning activities that increase study time also increase study results; (3) for both instructional interventions and learning activities, students reject the use of technology as being inefficient; and (4) domain of study is the only independent variable that consistently affects students' conceptions of instructional interventions. (Contains 13 references.) (SWC)

Homogeneity in students' conceptions about the efficiency of instructional interventions : Origins and consequences for Instructional Design

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Introduction

Research in educational psychology and instructional design has demonstrated that effects of instructional interventions are mediated by the interpretation and use by the learner (e.g. Elen, 1995; Winne & Marx, 1982). In order to explain these findings, it has been suggested (Elen & Lowyck, 1996; Lowyck & Elen, 1994) that in addition to learning-related metacognition which directs learning activities, another type of metacognition, instructional metacognition, must also be considered. Instructional metacognition may direct the interpretation and use of instructional interventions. It refers first of all to conceptions of students about the contribution that instructional interventions can make to their learning. As for metacognition in general (Brown, 1978; Flavell, 1979), it also refers to the impact of these conceptions on the interpretation and use of instructional interventions by students (Figure 1).

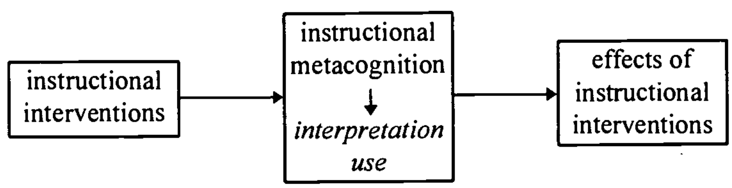

Figure 1 : Instructional metacognition as a variable mediating the effects of instructional interventions

Whereas the concept of instructional metacognition may be important as it provides a possibly powerful explanation of the lack of direct effects of regular instructional environments, it becomes even more important for so-called 'open' learning environments, or instructional settings in which the control is transferred from the environment or programme to the learner. In such settings, the learner him- or herself decides about the use of environmental elements in the absence of specific instructional incentives. An adequate selection and use of environmental elements for learning purposes requires an in-depth understanding of the potential of these elements for one's learning. In other words, in more open learning environments, learners become more responsible for their own learning and hence have to turn these environments themselves into instructionally valuable ones. They have to become their own instructional designers. Students' knowledge of instructional design, or broader, their conceptions about the relationship between environmental elements and their own learning, will determine the use they make of those environmental elements and hence about the effectiveness of those elements and their effects on learning.

In the recent past, some studies have addressed aspects of instructional metacognition. Some researchers, for instance, have investigated questions related to the content and structure of instructional metacognition and discrepancies between conceptions of students and of teachers (e.g. Levy, Wubbels, & Brekelmans, 1996; Stebler & Reusser, 1996). Other researchers, such as Ertmer and

Newby (1996) explored the impact of conceptions about case-based instruction on learning activities. Notwithstanding these studies, research on issues related to instructional metacognition is limited.

The complexity of instructional metacognition calls for a systematic research program (see : Lowyck & Elen, 1994). Given the variety of instructional interventions and the complexity of their relationship with learning, research on instructional metacognition within such a program can follow two main methodological directions. Studies may focus on one or a limited number of instructional interventions or aspects of the learning environment and investigate how different attributes of these interventions relevant to learning and instruction are conceived by students and affect learning (for case-based instruction, e.g. : Ertmer & Newby, 1996; for peer collaboration, e.g. : Stebler & Reusser, 1996). Or in a second approach, studies may focus on one or a limited number of attributes (e.g. effectiveness, structuredness). In this alternative approach a large number of instructional interventions or aspects of the learning environment may get investigated for a limited set of attributes.

In our own research, the second approach has been followed in a study analysing conceptions of students about efficiency-related attributes of instructional interventions and learning (Elen & Lowyck, 1996). Because data from this study constitute the starting point for the analysis presented in this paper, a brief summary of the findings seems appropriate. An analysis of survey data regarding efficiency-related attributes of instructional interventions and learning activities has revealed that (1) university freshmen are very obedient as they largely accept current school practices as being efficient. They regard both interventions (e.g. lectures) and learning activities (e.g. repeat regularly) mainly directed toward surface-level processing and reproduction to be highly efficient. These opinions of students reflect research on effective teaching in which the following characteristics of effective teaching have been revealed : clarity, structure, opportunity to learn criterion material, focus on academic activities (Dunkin & Biddle, 1974). (2) Whereas in students' conceptions there is a negative correlation between contributions to study results and study time of instructional interventions except for exams, a positive correlation is found between these two types of contributions for learning activities. This means that in students' conceptions interventions that contribute to an increase of study results, decrease study time, whereas learning activities that increase study time also increase study results (for an overview see Figure 2 and Figure 3). (3) For both instructional interventions and learning activities, students reject the use of technology as being inefficient. As Kinzie, Delcourt, and Powers (1994) suggest, this may be closely related to low feelings of self-efficacy with computers and limited experience with these instructional media. It may also be a reversed novelty-effect. (4) Finally, while some differences have been found, only domain of study (which of course is related to the specific learning environment students are experiencing) seemed to consistently affect students' conceptions of instructional interventions.

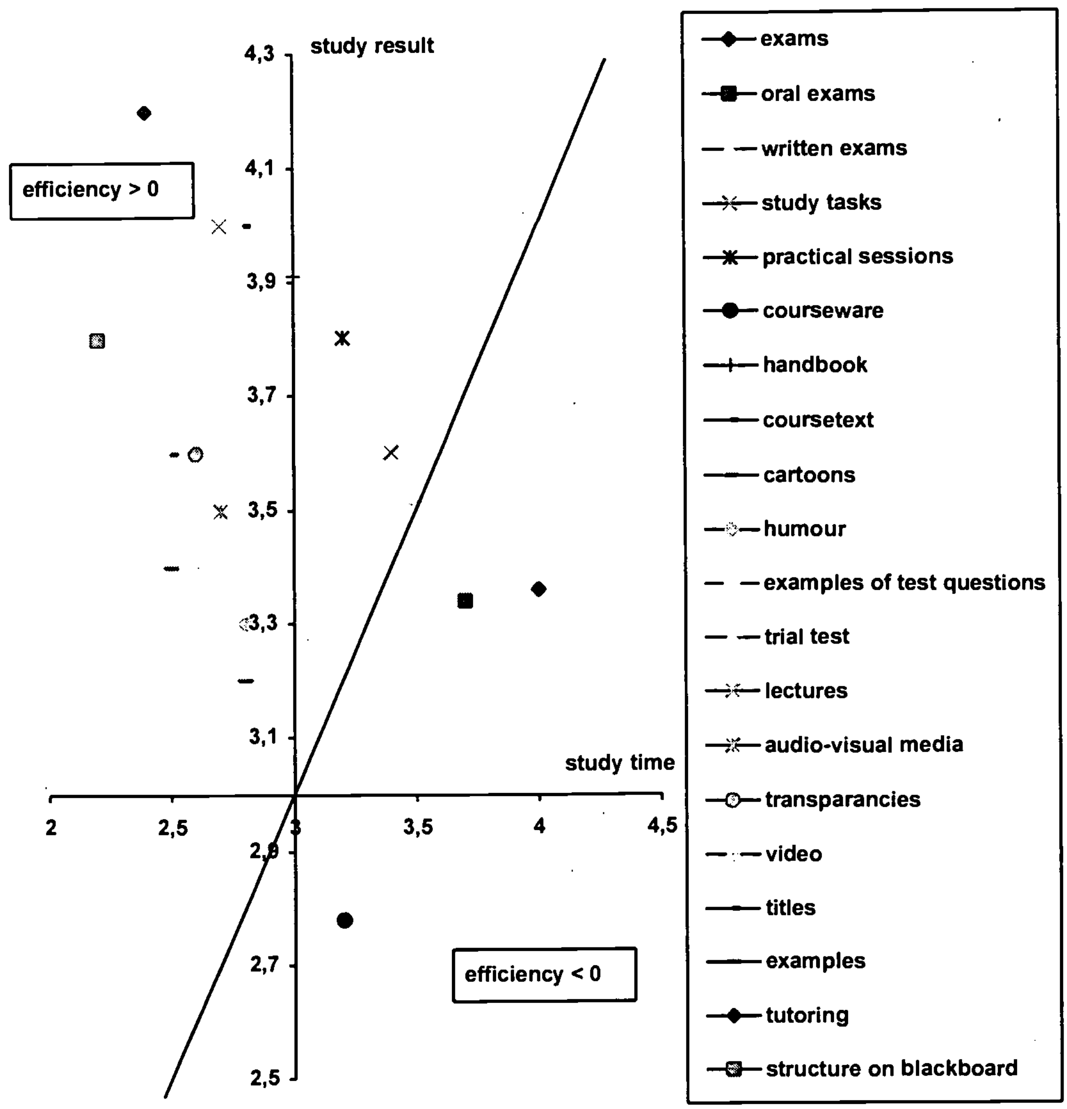

Figure 2 : The relationship between contribution to study time and study result for instructional interventions

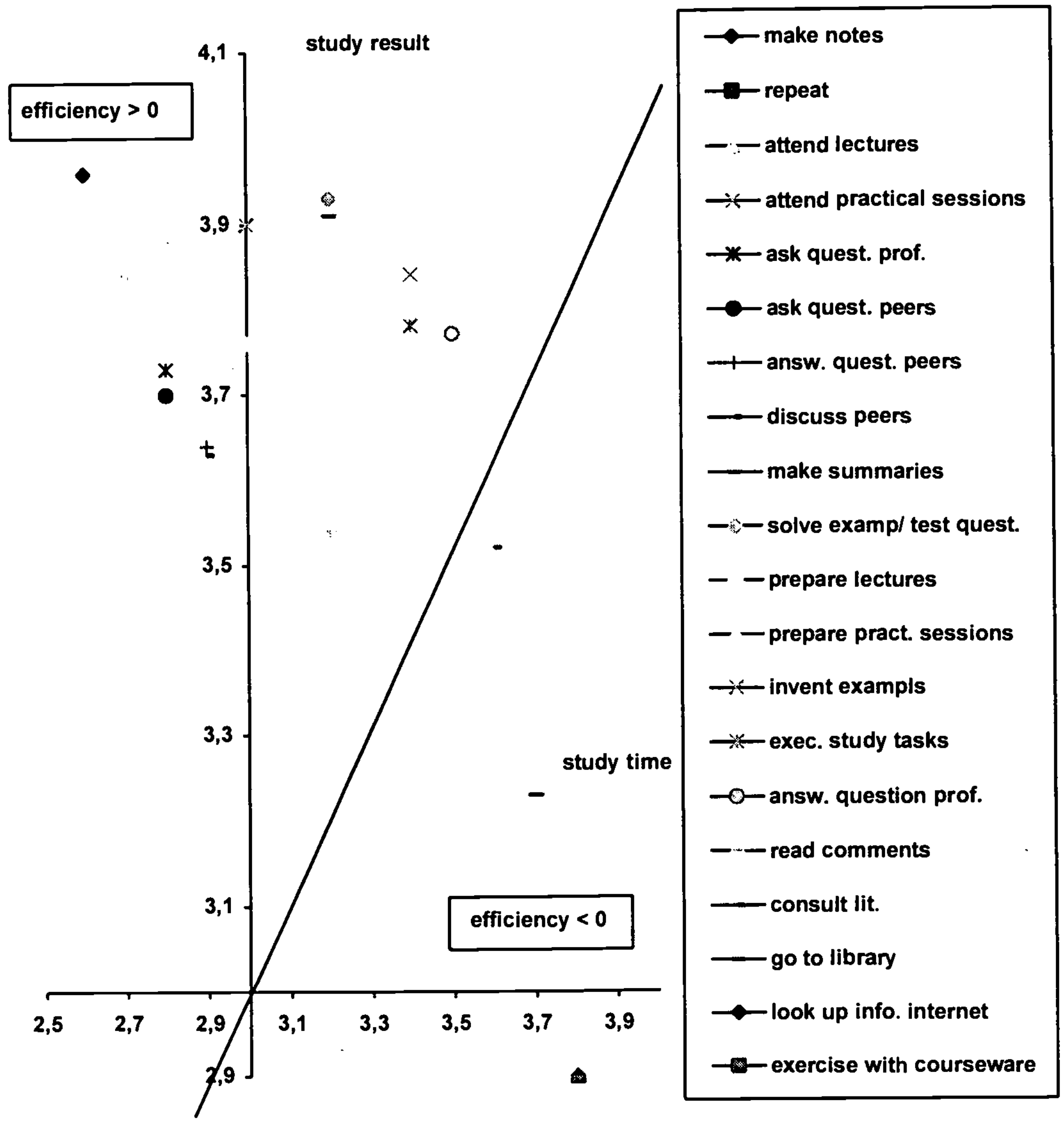

Figure 3 : The relationship between contribution to study time and study result for learning activities

Research questions

The study mentioned above suggested large homogeneity in students' conceptions about efficiency-related attributes of instructional interventions. In view of the elaboration of an instrument to more precisely assess 'instructional metacognition', the issue of homogeneity of students' conceptions was given priority in our research. The implications are indeed important. With a homogeneous set of conceptions, students can be treated as one group when these conceptions need change. At the same time, however, absolute homogeneity would provide no insight as to the origin and development of instructional metacognition. Hence, in case of homogeneity, there is no indication on where precisely to start to change conceptions.

At the core of this study, then, is the question whether different groups of students can be identified with respect to their conceptions about efficiency-related attributes of instructional interventions and learning activities. More concretely, it has been investigated whether groups of students can be identified that differ from one another in their rating of two attributes of instructional interventions and learning activities, namely contribution to study time and contribution to study result. Both instructional interventions and learning activities were considered as to further investigate the uniqueness of the concept of instructional metacognition.

Method

In order to answer the above mentioned questions data from a survey study that investigated the conceptions of students about the efficiency of instructional interventions and learning activities were re-analysed (Elen & Lowyck, 1996). Instructional interventions refer to instructional elements (e.g. lecture, courseware) or features of such elements (e.g. transparancies during lectures, cartoons in a coursetext). Learning activities refer to activities that are both initiated and executed by the student (e.g. making a summary, discussing with peers). In the survey study, university freshmen (N=489) ratings of efficiency-related attributes of instructional interventions and learning activities were investigated. The questionnaire consisted of (1) a number of identification questions (gender, domain of study and educational background), (2) a list of 20 instructional interventions and (3) a list of 20 learning activities both to be rated on a five point Likert-type scale for their contribution to study result and study time.

In order to get a more profound understanding of the origins of differences in students' conceptions gender, domain of study and educational background were included in the analysis as independent variables.

Repeatedly, past research has shown female students to have a more negative attitude toward computers than male students (for a review Lowyck, Elen, Proost, & Buena, 1995). It remains to be studied, though, whether gender differences in perceptions are typical for technological means or are more generic and do also appear when regular instructional interventions are investigated. Besides gender, it might be expected that given different recruitment profiles on the one hand and different instructional approaches on the other, students in different domains of study differ in their conceptions about the efficiency of both instructional interventions and learning activities. Therefore, in addition to the general question with respect to instructional metacognitive knowledge, gender and study domain differences are also included. Finally, in view of exploring the development of instructional metacognition, one may wonder whether differences in educational background also result in different perceptions about instructional interventions. With respect to educational background, level of secondary education has been considered.

Students from two domains of study have participated : educational sciences and psychology (see Table 1). As it is the case in the population of these two domains of study, female students clearly outnumber male students in the sample.

Table 1 : Description of sample : gender and domain of study

N	educational sciences	psychology	total
male	14	64	78 **15.95 %**
female	192	219	411 **84.05 %**
total	211 **42.13 %**	288 **57.87 %**	489 **100.00 %**

A second variable refers to an attribute of educational background, i.e. difficulty level of secondary education (Table 2). In view of determining the level of their secondary education, students were requested to indicate the number of hours of mathematics, Latin and Greek they attended weekly during the last year of secondary education. In Flanders the more hours followed in these domains the more difficult studies are regarded to be. Three groups of students can be identified : a high level group for students with 10 or more hours in these domains, a middle level group with less than 10 but more than 5 and a low level group with 5 or less than 5 hours of mathematics, Greek and/or Latin. Both generation (freshmen) and non-generation students (students who double their first year of study at the university) participated.

Table 2 : Description of sample : educational background

N	generation	non-generation	total
high level	148	15	163 **33.33%**
middle level	180	20	200 **40.90%**
low level	103	23	126 **25.77%**
total	431 **88.14%**	58 **11.86%**	489 **100.00%**

Questionnaires were administered during regular lecturing times after six months of experience with university teaching but before generation students experienced a cram-period. Questionnaires were filled out during regular lectures separately for psychology and educational science students. In total 489 students participated. However, complete data were available for 422 students.

Students rated 20 instructional elements and 20 learning activities on their contribution to overall study time and to learning outcome separately. Because the goal was to tap general conceptions of university freshmen, no specific context was provided. Students were instructed to think about instructional environments familiar to them and then rate the different elements and activities.

Results

In view of identifying groups of students, data were first analysed using principal component analysis with orthogonal varimax rotation as specified in the statistical package STATISTICA. Based on an analysis of the scree-plot and the eigenvalue criterion of one, a solution with three factors was selected. This solution explains 26.01% of the total variance.

Factor 1 explains 11.15% of the total variance. All items with high loadings (>= .40) on factor 1 address ratings by students of contributions to study time of instructional interventions and learning activities. Highest loadings (>= .75) are found for the ratings on contributions to study time of three learning activities : 'attend practical sessions', 'repeat regularly', and 'attend lectures'. Instructional interventions with highest loadings (>= .50) on this factor are : lectures, tutorial sessions, course notes written by a university teacher, and structure on the blackboard. Given these results the first factor may be said to refer to contribution to study time, with highest loadings for more traditional instructional interventions and learning activities immediately related to well-known instructional interventions that are externally steering the learning activities and processes.

Factor 2 explains 9.34% of the total variance. All items with high loadings (>= .40) on factor 2 address ratings by students of contributions of learning activities to study results. Two observations with respect to factor loadings on factor 2 are to be mentioned. First, all ratings of contributions of learning activities to study results load on factor 2 except for 'looking for information on Internet', 'exercise with some piece of courseware' and 'go to the library'. Second, none of the ratings of contributions of instructional interventions to study results load have factor loadings higher than .40 on factor 2. Highest loading on this factor (>=.70) are for 'attend practical sessions', 'repeat regularly', 'attend lectures' and 'invent examples oneself'. It can be concluded therefore that factor 2 refers to an assessment of conceptions about the effectiveness of well-known learning activities of university students. Highest loadings are found for activities that are appropriate in a direct teaching environment.

Factor 3 explains 5.52% of the total variance. All items with high loadings (>= .40) on factor 3 address ratings by students of contributions to study results of instructional interventions. Highest loadings (>=.55) are for the following instructional interventions : 'lectures', 'a handbook', 'tutorial sessions' and 'examples of exam questions'. Factor 3 then may be interpreted as referring to the contribution of traditional instructional interventions to study results.

As a first step towards the identification of groups of students, factor scores of individual subjects were plotted for each combination of factors (Figure 3). It can be seen in these scatter plots that conceptions of students do vary most for factor 1. Factor scores are calculated as the standardized sum of subjects' ratings for all items weighted by factor loadings.

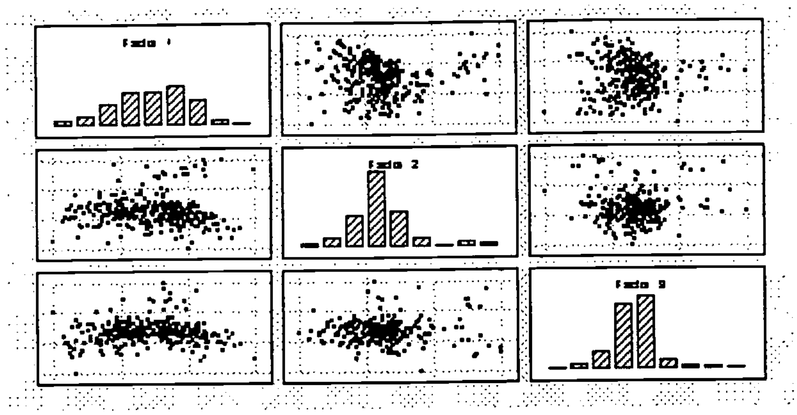

Figure 3 : Plots for combinations of factors

Next a cluster analysis using K-means clustering has been executed. In this approach the number of clusters is determined a priori. In the analysis which can be conceived as an inversed ANOVA, clusters are constructed in order to minimize variability within clusters and maximize variability between clusters. F values provide an indication of the significance of the differences between clusters. In this study, analyses with 2 or more clusters revealed the same overall results. The most parsimonous solution with two clusters will be presented.

A first cluster analysis on factorscores with the three factors as variables reveals two clusters.

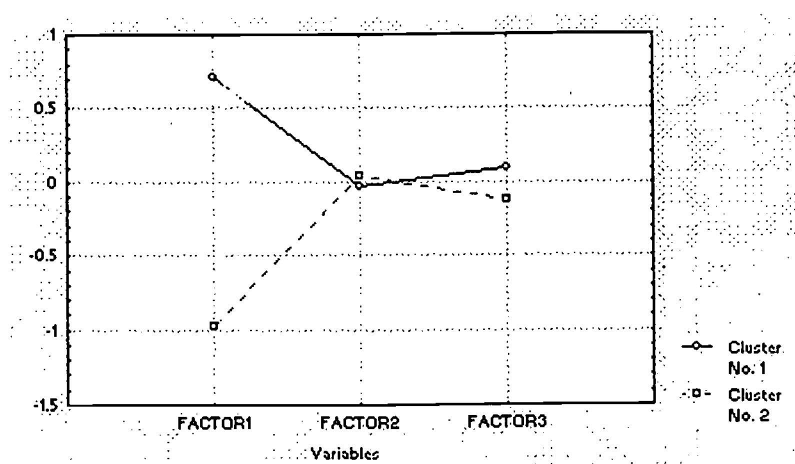

Figure 4 : Plot of means for two clusters

Clusters differ from one another significantly for factor 1 (F(1; 382) = 869.035, p<.000) but not for factor 2 and only marginally for factor 3 (F(1;382) = 4.280, p < .05). In other words, two groups of students can be detected that differ from one another based on their ratings of contributions to study time of traditional instructional interventions and learning activities immediately related to these well-known instructional interventions (Figure 4).

In order to further describe the two groups, a new cluster analysis was made considering factor scores on the three factors together with the above mentioned independent variables : gender, domain of study and educational background. Educational background here refers to the estimated difficulty level of secondary education of respondents. This selection of independent variables is exploratory. At this stage, it is unknown which variables mostly affect aspects of instructional metacognition.
Again a solution with two clusters was the most parsimonous one. As in the first analysis, these clusters differ from one another with respect to factor 1 (F(1; 382)=11.533; p<.00) but also with respect to educational background (F(1; 382)=1074.389; p<.00). No differences between clusters are found anymore for factor 3. In other words (see Table 3, Figure 5), students who estimate that traditional instructional interventions and learning activities immediately related to these well-known instructional interventions reduce study time, have a 'stronger' educational background whereas students with a 'weaker' educational background think these interventions and learning activities rather to contribute to an increase of study time. It is important to note that both groups do not differ with respect to the estimated contribution to study results of instructional interventions and learning activities.

Table 3 : Means for clusters

	Cluster 1	Cluster 2
Gender	1.17	1.18
Domain	1.44	1.38
Level	4.77	10.00
Factor 1 : contribution to study time of learning activities and instructional interventions*	-.17	.17
Factor 2 : contibution to study results of learning activities**	.01	-.01
Factor 3 : contribution to study results of instructional interventions**	.00	-.00

* a lower score indicates a contribution that increases study time, a higher score one that decreases study time

** a lower score indicates a contribution that increases study result, a higher score one that decreases study result

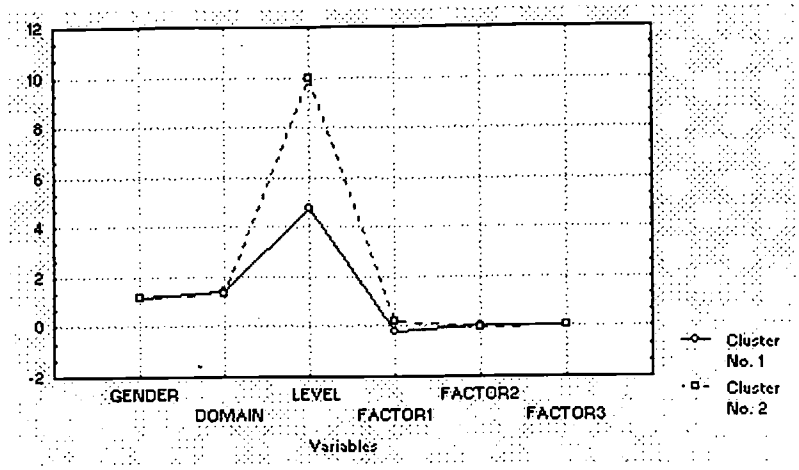

Figure 5 : Plot of means for two clusters with three factors and three independent variables

Conclusions

In this paper data from a survey study have been re-analysed in order to explore further the homogeneity of students' conceptions. This study is needed in view of the elaboration of an adequate instrument to measure instructional metacognition. It has been found that students conceive contributions of both instructional interventions and learning activities in a similar way. This suggests to make no difference between learning-related and instructional metacognition. However, for contribution to study results, results of principal component analysis reveals two factors, one for learning activities and another for instructional interventions. This, then, suggests to distinguish instructional metacognition from learning-related metacognition.

Cluster analyses have revealed two clusters. These clusters do not differ with respect to factor scores relating to contributions to study results, gender and domain of study. Clusters differ with respect to conceptions about contributions to study time of both learning activities and instructional interventions and level of educational background.

Students seem to differentially appreciate effectiveness and efficiency criteria. Effectiveness criteria are commonly perceived as important by all types of students, while students' conceptions differ with respect to efficiency criteria. Consequently, this research on a mediating variable, instructional metacognition, suggests to take into account these different positions and design different learning environments for reaching efficient instruction and learning.

The outcome of the cluster analysis is difficult to interprete. Several explanations could be brought forward. Results may suggest that students with a stronger educational background have experienced more frequently the contribution of traditional interventions and associated learning activities to a reduction of total study time. This may induce them to attend actively to these traditional interventions and engage in the specified learning activities. This explanation may also imply that students with a stronger educational background have been and will be more successful in their study. They are more eager to engage in adequate learning activities and use instructional interventions as they assume this to reduce study time. This implication is to be further studied. Similarly, the higher success rate is also to be investigated. Another explanation may be that students with a stronger educational background do consider contribution to study time as an issue whereas students with a weaker background do not. Students with a stronger educational background may have had to consider time when confronted with high demands in secondary education, whereas students with a weaker background may not have experienced any urge to actually consider time as an issue during studying. They may not see the relationship between study time and study result.

It needs further study to better understand why higher and lower level students conceive contributions to study time differently but not contributions to study result. It could be that a confrontation with questions that refer to a usual, regular situation does not elicit differential answers, since it lacks profile and thus hinders well-balanced and intruding reflection processes.

In terms of Derry (1996), the results suggest that with respect to study results, the mental objects and the cognitive field of students with both a strong and a weak educational background are similar. These similarities result in non-significantly different ratings of the contributions to study results of learning activities and instructional interventions. The different ratings for study time however reveal differences with respect to cognitive field and/or mental objects. This is to be further studied. The results also suggest that the relationship of learning activities and instructional interventions on the one hand and study result on the other is more evident than the relationship with study time. It might be that the estimated contribution to study results belongs to the same mental object as the learning activities and the instructional interventions, whereas contribution to study time only belongs to the cognitive field not the mental object of learning activities or instructional interventions.

This contribution is to be regarded part of a broader endeavour in which we want to construct a valid instrument to measure instructional metacognition and to identify different groups of students. The availability of such an instrument would enable us to monitor evolutions in students' instructional metacognition. It would also enable to design experiments with instructional metacognition as an important independent variable. The results add to the challenge to construct such an instrument.

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