Chapter 8
Quality and impact of the prior knowledge state on learning economics

1 Introduction

The present research discussed in this chapter is based on our earlier findings and can be considered as an attempt to validate a new approach to the evaluation of the quality and impact of the prior knowledge state in a specific domain. The specificity of our approach is described in part 2 of the text within the discussion of the background. In our approach, special attention is paid to the formulation of a set of prior knowledge state tests to measure the prior knowledge state components complexity. After summarizing the research procedure and the research results, the important implications which the study has for future investigations are discussed.

2 Background

The research described in this chapter is an attempt to grasp a student 's prior knowledge state and its impact on learning, by concentrating initially on the construction of a set of prior knowledge state tests and paying attention to the role of different prior knowledge state components. In past research, existing course-related tests were mostly used to assess prior knowledge (De Corte, 1991), without differentiating between types of the prior knowledge state along certain dimensions (Dochy, 1990).

This investigation focuses on the subject-oriented prior knowledge state (SO PKS) and cross-domain prior knowledge, i.e. the optimal requisite (OR) prior knowledge state, and the mathematics (MA) prior knowledge state.

Based on our earlier investigations in the preceding chapters, we expect that higher scores on subject-oriented and cross-domain prior knowledge state tests will result in higher scores on a post-test. We do not expect differences between student types (ES and LS), following the results of ex post facto research project 2 (chapter 6). Nevertheless, we repeated the analysis with the 'student type' variable, even though the current research focuses primarily on the quality of the prior knowledge state and its impact in terms of relationship to post-test scores. The main reasons for this are:

1. This investigation differs fundamentally from the former ex post facto research in the sense that there is a treatment of the experimental group.
2. Our focus on broader knowledge state tests could result in emerging differences as suggested in chapter 5.

In addition study time was introduced as an independent variable. According to the "accessibility" theory (Spilich, Vesonder, Chiesi and Voss, 1979) and the "representation-saving" theory (Johnson and Kieras, 1983), more prior knowledge

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leads to shorter study time. This is confirmed by our research among experts (chapter 3). Also, the explanatory model of Bruinsma and Geurts (1988) states that study time is a central factor in getting good study results. The basic idea behind all this is the connection between level of the prior knowledge state and study speed, resulting in higher scores.

3 Research design

3.1 Hypotheses

Taking into account the stated background of the current investigation, the following two groups of hypotheses can be put forward:

1. In respect of the quality of the prior knowledge state of ES and LS:
   - The overall prior knowledge state of ES and LS do not differ.
   - ES and LS do not possess a different range of the prior knowledge state components.

2. In respect of the relation between the prior knowledge state and the prior knowledge state levels and knowledge acquisition:
   - The prior knowledge state influences the post-test scores.
   - Specific prior knowledge state components influence the post-test scores.
   - Students with a better prior knowledge state obtain higher post-test scores.

3. In respect of the role of study time:
   - Shorter study time reflects higher levels of the prior knowledge state and results in post-test scores related through study time.

3.2 Research population

Subjects in this study are enrolled as students of the Economics and Law Faculties of the University of Limburg. The choice of this research population was based on several practical considerations and a number of research findings. Although the research is set up in an Open University context and it is our intention to apply the research results in this context, it is very difficult to involve a large sample of the OU population in experiments. This is especially true when the research requires grouping students studying a specific course and asking them to complete a specific task at a specific place on a specific date and time.
In our opinion, extrapolation of research findings from students involved in ordinary higher education to students in a OU setting is possible. Research has revealed, for instance, that personal and contextual variables are not significant

indicators of students' prior knowledge (Claeys et. al., 1981; Dochy, Bouwens, Wagemans, Niestadt, 1991), thus indicating that the type of university setting might have only a minor influence. The selected research population seems therefore to be appropriate for testing the particular set of hypotheses.

Aiming for a sample of a hundred subjects, 110 students were selected at random. From this initial sample, we were able to involve 88 (39 ES and 49 LS) subjects in the entire investigation procedure. It should be noted that the students, as in the subsequent studies, were payed to take part in the investigation and this in order to keep up motivation if necessary.

3.3 Research procedure

The research procedure consisted of several phases:

- Registration and introductory session.
  During this session, the main aim of the research project and the research procedure were outlined.
- Conducting the four prior knowledge state tests:
  SO KST1 (± 20 min.)
  OR KST (± 45 min.)
  ME KST (± 15 min.)
  MA KST (± 45 min.)
- A first study period (± 45 min.): during this study period the students studied the text of learning units 14 & 15 of the "Economics & Money" course. The study task was limited to the individual going through the course text. There was no control of individual approaches towards the study task. Text-support was the same as that provided in normal OU-courses.
- Lunch time (30 min.)
- During a second study period (± 45 min.), the students were allowed to continue with their study of the course text.
- Conducting the SO KST2 post-test (± 15 min.).
- Concluding session.

The set of prior knowledge state tests was a specific feature of this research as explained in the introduction. The procedure was conducted according to a strict time schedule, but avoiding time stress or fatigue. In this way, the net study time (i.e. the time effectively utilized for studying) was registered. Nevertheless, we are aware of the fact that students were not used to this balance between testing and learning, which could possibly have influence on the results.

4 Research results and discussion

4.1 General results

Table 1 gives an overview of the mean scores and the standard deviation of the student scores for the four different prior knowledge tests and the post-test:

Table 1: Mean scores for the prior knowledge tests and the post-tests

	m	σ
SO KST1	5.0	2.05
OR KST	8.5	3.84
ME KST	3.6	1.89
MA KST	12.8	5.43
SO KST2	6.6	1.77
PKST1	30.0	9.87
PKST2	21.4	6.92

To calculate a general measure of the prior knowledge state, the scores for the four prior knowledge tests have been added to each other (PKST1). Correlation analysis between the four prior knowledge state tests reveals that the optimal requisite test and the mathematics-test do correlate to a high degree (.635**)[1]. This is to be expected, since the optimal requisite test contains questions, based on the mathematics domain. Since both tests measure, to a certain extent, the same type of prior knowledge state, a second general measure of prior knowledge has been calculated, excluding the scores for the optimal requisite test (PKST2).
The mean and standard deviation of both general measures of the prior knowledge state can also be found in table 1.

4.2 The quality of the prior knowledge state in economics

4.2.1 Testing the hyphothesis that the overall prior knowledge state of Economics Students (ES) and Law Students (LS) is not different

Analysis of variance of the overall prior knowledge state scores (PKST1 & PKST2) of ES and LS reveals significant differences in the prior knowledge state level of

[1] ** $p < .001$

the two groups[2]. Table 2 shows the mean scores of the two groups of students, the maximum score and the analysis of variance statistics.

Table 2: Differences in the prior knowledge state between LS and ES

	m					MCA	
	ES	LS	max	F	p_F	ES	LS
PKST1	35.94	22.38	59	76.38	.000	6.01	-7.55
PKST2	25.37	16.33	51	63.61	.000	4.00	-5.03

The second part of the table shows the results of the multiple classification analysis. The mean deviance of the mean of ES is always positive, while that of LS is always negative. These significant differences in the prior knowledge state between ES and LS are in contradiction with our earlier findings (Chapter 6). In our opinion this may be due to the effort made in the latest project to develop a variety of instruments to measure the prior knowledge state. Consequently the instruments were more sensitive measures of differences in the prior knowledge state. This makes a comparison of the composition of prior knowledge state components in the two groups of students particularly interesting.

4.2.2 Testing the hypothesis that ES and LS do not possess a different composition of the prior knowledge state components

As expected from the former analysis, there are specific differences in the composition of the prior knowledge state components in LS and ES[3]:

[2] The variances of ES and LS are equal for both general measures of the prior knowledge state (t-test).

[3] The variances of the test scores of ES and LS are equal for the 4 different measures of components of the prior knowledge state (t-test).

Table 3: Differences in the prior knowledge state components between LS and ES

	m					MCA	
	ES	LS	max	F	p_F	ES	LS
SO KST	5.73	4.05	12	17.44	.000	.75	-.95
OR KST	10.57	6.05	8	45.54	.000	2.00	-2.52
ME KST	3.98	3.10	11	4.84	.030	.39	-.49
MA KST	15.65	9.18	28	47.18	.000	2.87	-3.60

The results in table 3 are very consistent. With the exception of the test scores for ME KST ($.001 > p < .05$), there is a significant difference between ES and LS in relation to the specific prior knowledge state components. Moreover, each time the same trend is to be found (see mean scores and MCA): the prior knowledge state level of ES is higher than the prior knowledge state level of LS. These differences are extremely high for the optimal requisite test and the mathematics prior knowledge state test. As indicated earlier, the optimal requisite test correlates to a high extent with the mathematics prior knowledge state test since the former contains mathematics questions. This implies that the SO KST and the MA KST seem to be most important for describing differences in the prior knowledge state between ES and LS. This finding could be of interest when looking at the potential impact of the prior knowledge state on learning. Has, for example, the mathematics prior knowledge state an important impact on learning subject-oriented knowledge in relation to economics?

4.3 The impact of the prior knowledge state on knowledge acquisition

4.3.1 Testing the hypothesis that the prior knowledge state influences the post-test scores

In order to be able to measure the impact the prior knowledge state has on learning new economics knowledge, a subject-oriented post-test[4] was set to all students after an experimental treatment. During this treatment, all students received a specific study task.

To detect the impact of the prior knowledge state on knowledge acquisition, regression analysis has been used to define the extent to which the prior knowledge scores help to explain the variance in the results for the post-test.

[4] This posttest was a parallel version of the SO KST. Both tests reflect the subject-content dealt with during the study task.

Table 4: Regression analysis of general the prior knowledge state scores

	R^2
PKST1	.17
PKST2	.16

The results in table 4 indicate that the prior knowledge state- as measured by the four (PKST1) or three (PKST2) prior knowledge state tests - helps to explain 16 to 17% of the variance of the post-test results.
Although this impact is significant, it might be considered that this figure is still relatively small. Other variables - related to the prior knowledge state or other independent variables - seem to influence the post-test scores. Nevertheless, taking into account the conclusion of part 4.2, it might be interesting to look at the complex of the prior knowledge state components to determine a further quantitative analysis what type of prior knowledge state contributes to the 16 - 17% of explained variance (R^2 = explained variance).

4.3.2 Specific prior knowledge state components influencing the post-test scores

If we enter all the test scores in the regression equation, we get the following picture, indicating the extent to which each separate prior knowledge state test contributes to the variance in the post-test scores.

Table 5: Regression analysis of the prior knowledge state component scores

	R^2
SO KST1	.07
OR KST	.11
ME KST	.01
MA KST	.13

Even at this level it is already apparent that the mathematics prior knowledge state test (MA KST) and the optimal requisite test (OR KST) explain a large proportion of the variance in the post-test scores. But a further analysis is needed to determine exactly what the specific contribution of each prior knowledge state is. In order to do this, a stepwise regression analysis has been carried out[5]. Only the mathematics

[5] Taking into account the high intercorrelation between the optimal requisite KST and the mathematics KST, it is expected that not all prior knowledge state scores will be entered in the regression equation.

prior knowledge state test and the subject-oriented prior knowledge state test (SO KST) are withheld and entered in the regression equation. Both tests then explain 13% of the variance in the post-test results. The scores for the optimal requisite test correlate highly with the MA KST scores and the subject-oriented prior knowledge state test does not seem to add much in this stepwise analysis.
These results do confirm the predominant impact of optimal requisite and mathematics prior knowledge state in the learning of economics, and lesser impact of subject-oriented knowledge.

4.3.3 Testing the hypothesis that students with a better prior knowledge state obtain higher post-test scores

To check this hypothesis, the results of two sub-groups of students have been used. The scores of the 25% of the students with the highest scores (H) and the scores of the 25% of the students with the lowest scores (L) for the prior knowledge state in general (PKST1 & PKST2) and for each of the specific prior knowledge state tests have been used in the analysis[6]. This means that the middle group was ignored (this group will be tackled in chapter 10). We checked whether students with high or low scores for the specific prior knowledge state tests also obtain significantly different results in the post-test[7] (analysis of covariance).

[6] The letter L and H in the table refer to the group with **Low** scores and the group with **High** scores for each specific prior knowledge state test.

[7] The mean scores of the high and low group for the specific prior knowledge state tests are significantly different ($p < .0005$).

Table 6: The relation between low and high scores for the prior knowledge state tests and the post-test scores

	m				MCA	
	L	H	F	p_F	L	H
PKST1	5.09	7.21	18.90	.000	-1.01	1.01
PKST2	5.18	7.19	17.40	.000	-1.09	.92
SO KST	5.81	6.73	4.41	.04	-.54	.38
OR KST	5.28	6.65	7.96	.007	-.79	.58
ME KST	5.88	6.30	.68	.41	-.21	.20
MA KST	5.73	7.17	9.95	.003	-.74	.71

Having a low or high prior knowledge state score (PKST1 & PKST2) is significantly reflected in differences in post-test scores. When looking at the specific prior knowledge state tests, we can also conclude that, with the exception of ME KST, the hypothesis that differences in the prior knowledge state scores are mirrored by post-test scores appears[8]. Students with high prior knowledge state scores obtain high post-test scores[9].

4.4 The role of study time

In order to detect the potential effect of study time on the learning of new economics knowledge, the time taken by students to complete the study task was registered. This study time varied from 62 minutes to 130 minutes. To make a further analysis of the study time-related hypothesis, students were divided into three groups, based on their study time[10].

Analysis of variance revealed that the differences in study time are not reflected in significant differences in prior knowledge state scores (general measure of the prior knowledge state (PKST en PKST2) and the prior knowledge state components). Multiple regression analysis shows that study time makes no contribution to explain the variance in post-test scores (see Dochy, Valcke and

[8] In relation to the first prior knowledge state test (SO KST1) the hypothesis is confirmed at the 5% level ($p < .05$).

[9] This analysis has been replicated in another sense : 25% of the students with the highest and lowest scores for the posttest have been compared in relation to their prior knowledge state test scores. The results of this analysis (t-test) are consistent with the results in table 7 : PKST1 ($t=-3.65$, $p_t=.001$); PKST2 ($t=-3.73$, $p_t=.000$); SO KST1 ($t=-2.70$, $p_t=.009$); OR KST ($t=-2.5$, $p_t=.01$); ME KST ($t=-.89$, $p_t=.378$); MA KST ($t=-3.34$, $p_t=.001$).

[10] 1 = < 77'; 2 = > 76' and < 87'; 3 = > 86'.

Wagemans, 1991).

5 Conclusions

The results of this study concerning the quality and impact of the prior knowledge state in economics has revealed some relevant results with implications for the content and organisation of education in the field of economics.

The first conclusion is that the variable "student type" (ES or LS) has been helpful to detect differences in prior knowledge state within a population of students. Moreover, these differences could be extrapolated in terms of specific components of the prior knowledge state. The differences in mathematics prior knowledge state and optimal requisite prior knowledge state between both sub-populations were striking. These facts call into question the multi-functional nature of the "Economics and Money" course and imply a need for structural, organisational or educational adaptations of this course to take account of these differences.

The second important conclusion of this research is that it could be stated that the level of prior knowledge state predicts, to a certain degree, future learning results of students. Although the predictive power of the prior knowledge state tests used is still limited (16-17%), further analysis reveals that most of the predictive power is related to optimal requisite knowledge and especially to mathematics.

Third, the results show that study time is not a relevant independent variable, reflecting differences in the prior knowledge state and having an impact on learning new subject matter. This variable does not help to explain variance in the post-test scores and differences in study time are not reflected in significant differences in posttest scores.

The results are also helpful in indicating possible directions for further research. For instance, a further examination and analysis of the complex of components making up the prior knowledge state would seem worthwhile (see chapter 9). In addition, much might be learned from research which defined prior knowledge state components other than in terms of subject-matter, as was done in the research reported here. Such alternative definition 'dimensions' will be put forward in chapter 10.