Chapter 9
Investigating the impact of prior knowledge state components

1 Introduction

This study is elaborating on the results of the study reported in chapter 8, replicating most of the hypotheses, but involving a different student population. There are a number of reasons for adopting this approach to the research questions about the quality and impact of the prior knowledge state, but the particularities of the OU population is of primary importance. Earlier experiences have shown that it is extremely difficult to involve a large number of Open University students in such a study. They are e very heterogeneous group, dispersed throughout the country, many with non-study commitments. Because the Maastricht student population, for reasons such as attainability and continuation, is much easier to investigate, our previous research has been carried out with Maastricht University students. From an earlier investigation (chapter 6) we concluded that contextual and personal variables are not valid indicators of a student's prior knowledge. This is in accordance with the findings of earlier research (Powell, Conway and Ross, 1990). Moreover, this already suggests that the Maastricht research results - although collected from a population with different contextual and personal characteristics - might be transferred to the OU research and education context. However, more research is needed to support the feasibility and acceptability of this transfer. This can be called our 'context-transfer hypothesis'. The main hypotheses of the research described in this chapter have already been tested with the ordinary university student population (chapter 8).

Further, we try to find out more concerning the contribution of different prior knowledge state components in explaining posttest variance.
To look for additional support for the hypotheses about quality and impact of the PKS and its components and to look for support for our context-transfer hypothesis, the present study has been set up. Moreover, we shall test a hypothesis concerning student estimation of their prior knowledge state level.

The specificity of this approach is described in part 2 of the text within the discussion of the background for this investigation. After summarizing the research procedure and the research results, the implications which the present study has for future investigations are discussed.

2 Theoretical background

Previous research results (chapter 8) indicate a certain role of different prior knowledge state components, as mentioned before. Research, focusing on the detection of specific measures of the prior knowledge state which can shed light on specific components of the prior knowledge state, could possibly lead to new

approaches towards the prior knowledge state. The research described in this chapter has precisely this objective; we want to determine a student's prior knowledge state and its impact on learning, by concentrating initially on the formulation of a set of prior knowledge state tests and on the role of the different components they measure. In past research, existing course-related tests were mostly used to assess prior knowledge (De Corte, 1990b), without differentiating between particular types of prior knowledge state (Dochy, et al., 1990e). In our approach, attention is paid again to the construction of a set of PKS tests to measure a complex of prior knowledge state components. In chapter 7 we explained how we constructed 1.1 versions of our PKST for this investigation.

As an additional approach to determining the prior knowledge level of the students, we asked the students themselves to estimate their mastery level. In an experiment by Lodewijks (1981), it was shown that prior knowledge could account for 36% of the explained variance in post-test scores. In this instance prior knowledge was considered to be the subjective rating of familiarity with the content of the learning task. However, when considering the Falchikov and Boud (1989) meta-analysis of 48 student self-assessment studies, the researchers came to more differentiated conclusions: most studies found positive effect sizes, indicating overrating on the part of the students. It appears that more experienced students in a particular field (that is, students with more prior knowledge) are more accurate estimators, whereas students taking introductory courses appear to make particularly inaccurate self-assessments.

3 Research design

3.1 Hypotheses

Taking into account the background of the current investigation, the following three groups of hypotheses can be put forward[1]:

1. In respect of the quality of the PKS in ES and LS:
   - The overall PKS of ES and LS does not differ.
   - ES and LS do not possess a different range of PKS components.
2. In respect of the impact of the PKS and PKS levels on knowledge acquisition:
   - The PKS influences the post-test scores.
   - Specific PKS components influence the post-test scores.
   - Students with a better PKS obtain higher scores for the posttest scores.

[1] Although a third category of students (other students=OS) was involved, we will mainly focus our hypotheses and analyses on ES and LS.

3. - Students' estimations of their PKS levels do not reflect their measured PKS levels (i.e. as measured by PKS tests).

3.2 Research population

In the present study, students learning in a distance education setting, in particular students at the Open University were involved (January 1991).

It is difficult to bring together a large and representative sample from this research population. Our earlier research showed several reasons for this. First, one has to take account of the normal drop-out rate of nearly 60% at distance teaching universities. Second, students choose the Open University deliberately because of the large degree of freedom: free choice of study time, study place, study pace, etc. Consequently an experiment at a certain time, at a certain place, in which study at a certain pace is expected is unlikely to appeal to such students. Third, although we know that in open learning situations 50-60% of those approached may be expected to answer a simple questionnaire, it is also known that with true learning tasks in experimental settings only 10% of the initial sample persists. As a consequence, the experimental group in the present study is limited in number (n=15). This can prevent us probably from obtaining 'statistically' significant results. In order to reach these students, we took a representative sample of students newly enroled for the 'Economics and Money' course. The students in this sample, all registered at the OU study centre in Amsterdam, were asked whether they were able to participate in the experiment.

Of the final group of respondents who participated in the experiment, 7 students were identified as ES, 4 students as LS, and the rest studied a combination of disciplines or had not decided on a specific discipline yet.

3.3 Research procedure

The research procedure consists 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 PKS tests:
  SO KST1 (± 50 min.)
  OR KST (± 40 min.)
  MA KST (± 45 min.)
- Lunch time (30 min.)
- A study period (± 90 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.
- Conducting the post-test SO KST2 (± 50 min.).

The improvement of the set of prior knowledge state tests was a specific feature of this research as explained in chapter 7. The procedure was conducted according to a strict time schedule, while avoiding time stress or fatigue.

4 Research results and discussion

4.1 General results

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

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

	m	σ
SO KST1 (n=15)	10.27	3.89
OR KST (n=15)	9.00	10.53
MA KST (n=15)	8.60	7.34
POSTT (n=15)	13.20	6.23
PKST1 (n=45)	27.87	19.45
PKST2 (n=30)	19.26	12.78

To calculate a general measure of the PKS, the scores for the three prior knowledge tests have been added to each other (PKST1). Correlation analysis between the four tests reveals that the optimal requisite test and the mathematics test do correlate to a very high degree (.89**)[2]. This is to be expected, since the optimal requisite test contains questions, based on mathematics. Since both tests measure, to a certain extent, the same type of PKS, a second general measure of prior knowledge has been calculated, excluding the scores for the mathematics test (PKST2). The mean and standard deviation of both general measures of the PKS can also be found in table 1.

4.2 The quality of the PKS in studying economics

[2] ** = $p < .001$

4.2.1 Testing the hypothesis that the overall PKS of students of different diploma type does not differ

Analysis of variance of the overall PKS scores (PKST1 & PKST2) of students of different diploma type reveals non-significant differences in PKS level of the three groups. Table 2 shows the mean scores of the three groups of students and the analysis of variance statistics. Diploma type ES refers to "Economy Students", LS to "Law Students" and OS to "Other diploma type Students"[3].

Table 2: Differences in PKS between ES, LS and OS

	m					MCA		
	ES	LS	OS	F	p_F	ES	LS	OS
PKST1	40.17	16.00	24.25	2.74	.104	12.30	-11.87	-3.62
PKST2	27.00	10.60	18.50	2.85	.097	7.73	- 8.67	-.77

However, the results of the multiple classification analysis (MCA), as shown in table 2, reveal consistent trends. The mean deviation of the mean of ES is always positive while that of the mean LS and OS is always negative. The fact that the differences are not statistically significant might be due to the small number of students involved in this study. Since, in the present study, attention has been paid to making the research instruments as sensitive to differences in components of PKS as possible a comparison of the present composition of PKS components in economics, law and other students is particularly interesting.

4.2.2 Testing the hypothesis that ES and LS do possess a different composition of PKS components

Based on the former analysis and the results of our earlier study, we expected that there would be specific differences in the composition of PKS components in ES and LS. As explained earlier, due to problems associated with the student population in distance learning, we entered a third category of other diploma type students (OS).

Table 3: Differences in PKS components between LS, ES and OS

	m					MCA		
	ES	LS	OS	F	p_F	ES	LS	OS

[3] This type of students comprises business studies students, students following a very varied set of courses and students whose final diploma type was at the time of the study not predefined.

SO KST1	11.00	9.40	10.25	.19	.826	.73	-.87	-.02
OR KST	16.00	1.20	8.25	3.79	.053	7.00	-7.80	-.75
MA KST	13.17	5.40	5.75	2.30	.143	4.57	-.320	-2.85

Although the results in table 3 do not reveal any statistically significant differences in the PKS components between the students of different diploma types, multiple classification analysis does confirm the trends found in the former part of this text. At each level, the ES obtained higher test scores than the other students. Again, the non-significance of the trends detected might be due to the small number of students in the experimental group. The differences between the student types are remarkable (and nearly significant at the 5% level) for the optimal requisite PKS test (OR KST).

The latter finding could be of interest when looking at the potential impact of the PKS on learning. Has, for example, the PKS as defined by the optimal requisite test, an impact on learning subject-oriented knowledge in relation to economics?

4.3 The impact of the PKS on knowledge acquisition

4.3.1 Testing the hypothesis that PKS influences the post-test scores

In order to measure the impact of the PKS 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 PKS 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.

Table 4: Regression analysis of general PKS scores

	R^2	% explained
PKST1	.368	37%
PKST2	.419	42%

The results in table 4 indicate that the PKS - as measured by the PKST1 or the PKST2 - helps to explain 37% to 42% of the variance of the post-test results. This impact is statistically significant. Moreover, compared to the results obtained in our

[4] This posttest was a parallel version of the SO KST1.

earlier study (chapter 8), we obtained a much higher percentage of explained variance. The detected impact of the PKS is comparable to the results obtained by others (Schmidt, 1987). This result also indicates that the optimization of the research instruments has an impact on their sensitivity as measures of the differences in PKS.
As a consequence, it might be interesting to look at the complex of PKS components to determine what type of PKS contributes to the high percentage of explained variance.

4.3.2 Testing the hypothesis that specific PKS components influence the acquisition of economics knowledge

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

Table 5: Regression analysis of the PKS component scores

	R^2
SO KST	.198
OR KST	.353
MA KST	.218

Even at this level it is already apparent that the prior knowledge state as measured by the optimal requisite test (OR KST) explains a very 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 PKS component is. In order to do this, a stepwise regression analysis has been carried out[5]. Only the optimal requisite PKS test is restrained and entered in the regression equation. The test explains 35% of the variance in the post-test results. The scores for the mathematics PKS test and the subject-oriented PKS test do not seem relevant (PIN =.05) or significant.

Since the instruments used in this research project seem to be more sensitive to differences in the PKS, a further analysis of the general PKS scores might be interesting. Entering the two general measures of the PKS (PKST1 & PKST2) in the regression equation might give us more support for findings concerning the role of specific PKS components.

The results in table 5 confirm the predominant impact of the optimal requisite PKS in studying economics. But it is interesting to note that the second general

[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.

measure of the PKS, comprising the optimal requisite test scores and the test scores for the subject-oriented PKS test, helps us to explain up to 42% of the variance in the post-test scores. This rather high figure helps to get a fuller picture of the components of the PKS required for studying economics.

4.3.3 Testing the hypothesis that students with a better PKS obtain higher post-test scores

To check this hypothesis, the results of two sub-groups of students have been used. The scores of the 50% of the students with the highest scores (H) and the scores of the 50% of the students with the lowest scores (L) for PKS in general (PKST1 & PKST2) and for each of the specific PKS tests have been used in the analysis[6]. We checked whether students with high or low scores for the specific PKS tests, also obtain significantly different results in the post-test[7].

[6] The letters 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. Because of the limited number of students in the experimental population, we could not use the 25% measure to split up low and high groups as in our earlier research project. The number of students in each sub-group would then have been even more restricted.

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

Table 6: The impact of low and high scores for PKS tests on the post-test scores

	m				MCA	
	L	H	F	p_F	L	H
PKST1	10.25	16.57	4.90	.04	-2.95	3.37
PKST2	10.86	15.25	1.98	.18	-2.34	2.05
SO KST	11.57	15.63	.89	.36	-1.63	1.43
OR KST	10.25	16.57	4.90	.04	-2.95	3.37
MA KST	12.14	14.13	.36	.56	-1.06	.93

The results in table 6 confirm show that the differences are not significant, which will probably due to the restricted number of students in the investigation group. The trends are consistent: Low PKS students obtain lower results for the post-test than high PKS students. The results of other OU study centres will have to show if this trend is significant for these too.

4.4 Testing the hypothesis that students' estimations of their PKS levels do not reflect their measured or 'real' PKS levels

As explained in the introductory chapter (chapter 7), earlier research revealed that students are generally unable to accurately estimate their own PKS level. In this research project, prior to the administration of the PKS tests, students were asked to indicate on a 4-point-scale their degree of prior knowledge (1=low 4=high). Table 7 gives the results of the analysis of variance.

Table 7: The interrelation between estimated and real PKS

	Estimated PKS Level						MCA			
	1	2	3	4	F	pF	1	2	3	4
PKST1	41.7	13.0	26.8	26.0	.19	.83	13.6	-15.15	-1.35	-2.15
PKST2	27.0	9.0	18.6	21.0	1.05	.42	7.8	-10.15	-.55	7.85

Table 7 shows that the differences in PKS estimated by the students are not reflected in the levels of PKS as measured by the tests. Striking is the under-estimation of their real PKS level by the lowest self-assessment group. This group (self-assessment PKS level = 1) shows mean total scores on the tests which are higher than those for other level groups (see figure 1 and 2).

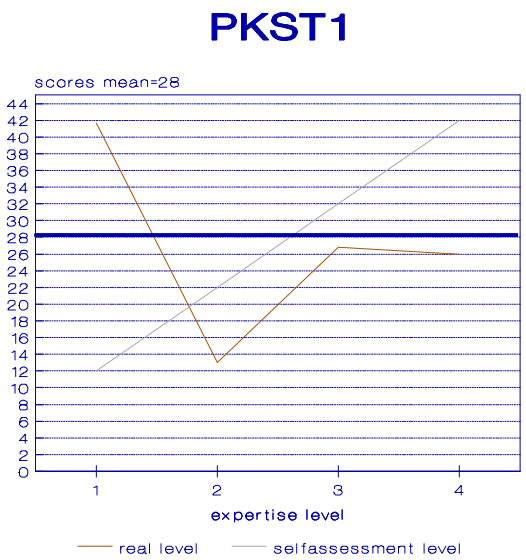

Figure 1: Differences between self-assessment levels and real PKS levels (PKST1)

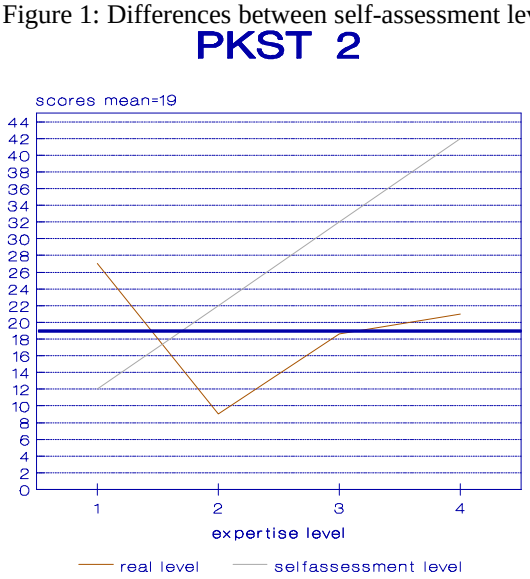

Figure 2: Differences between self-assessment levels and real PKS levels (PKST2)

5 Conclusions

The results of this study concerning the quality and impact of the PKS in economics has revealed some relevant results with specific implications.

The first conclusion is that the variable "student type" (ES or LS) has not been helpful to detect differences in overall PKS within a population of students. However, these differences could be extrapolated in terms of specific components of PKS. The differences in optimal requisite knowledge and mathematics PKS

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 of educational adaptations of this course to take account of these differences.

The second conclusion of this research is that it could be stated that the level of PKS predicts, to a certain degree, future learning results of students. It should be noted that the second general measure of the PKS (PKST2),
comprising the optimal requisite test scores and the test scores for the subject-oriented PKS test, explains up to 42% of the variance in the post-test scores. Further analysis revealed optimal requisite knowledge is an important component of the student PKS.

Further, it was shown that the estimation of PKS level through self-assessment by the students is not very reliable. The estimations do not reflect the levels of PKS as measured by the objective tests. For our purpose, it can be concluded that self-assessment is not useful, at least not for introductory courses, as also shown by Falchikov and Boud (1989).

Concerning the context-transfer hypothesis, the present study shows the same trends as in the results of our former study and provides another bit of evidence that research results obtained from the UL population can be extrapolated to the OU population (Dochy, Valcke and Wagemans, 1991). This is to be expected since students with the same characteristics as regular university students are part of the OU population.

The results of this study are helpful to 'indicate' directions for further research, notwithstanding the fact that research population is difficult to reach and the experimental group was relatively small. We are well aware that this sample size may account for not finding certain statistically significant results.

However, the differences found in chapter 8 are mirrored in the multiple classification analyses of this investigation.
Investigations in other OU study centres will have to conform these trends as significant there too.

Anyway, it looks promising to analyze in more detail the complex of components of the PKS. Much might be learned from research which defined the prior knowledge state components other than in terms of subject-matter. In chapter 10, other dimensions, such as psychological and epistemological dimensions, will be put forward.