Epistemological Beliefs in Finnish Upper Secondary Education

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Abstract

The study examines upper secondary school (in Finnish: *lukio*) students' epistemological or epistemic beliefs – their conceptions of knowledge, science and learning. The aim of the study is to discover correlations between the students' epistemological beliefs and their reasoning skills or their level of formal operations. The results indicated that a higher level of cognitive development in terms of formal operations is accompanied by what Schommer terms "sophisticated personal epistemology". In the present study, three of Schommer's five sophisticated epistemological beliefs were associated with a higher level of formal operations. Furthermore, the results for the other two beliefs did not directly contradict the Schommerian framework – they simply did not predict any particular level of formal operations or academic success. The three beliefs that were associated with a higher level of formal operations included a conception of knowledge as complex rather than simple and as tentative rather than certain and the students with a higher level of formal operations were more inclined to think that learning requires time and effort instead being a matter of quick intuition.

1 Introduction

Learning does not happen solely according to spontaneous and subconscious mechanisms; we entertain notions concerning ourselves as learners as well as more general ideas concerning the nature of knowledge and learning. Metacognition has been the object of some interest since the late 1970's (cf. e.g. Flavell 1976). The hypothesis that metacognitive notions can predict students' abilities and confidence as learners has also gained support in empirical studies. However, although the relevance of metacognition for learning has been demonstrated, there is arguably work to be done in elaborating its different dimensions and its exact nature and relation to learning.

The guiding idea in this paper and in the study of epistemological beliefs in general is that *metacognition* correlates with *cognition*. In other words, my hypothesis is that students' cognitive skills and academic success can be inferred from their views concerning knowledge and learning – their epistemological or epistemic beliefs. Schommer (1990) categorised five dimensions of epistemological beliefs: 1) simplicity/complexity of knowledge, 2) certainty/tentative nature of knowledge, 3) trust in authority/criticality, 4) innateness of the ability to learn 5) quickness/laborious nature of learning. The basic idea is

that the views that enhance learning tend to endorse complexity, tentativeness, criticality etc., whereas the restrictive mindsets tend to favour simplicity, certainty, obedience etc.

Of course, a positive correlation between cognitive skills and metacognition does not imply a relation of causality between them. Furthermore, even if such causality were plausible, it is not evident which way the arrow of causality points; are positive epistemological beliefs the source of academic success or the other way around? This question cannot be answered on the basis of the present study, but I would suggest that the influence can be reciprocal and that the teacher can foster learning by improving the students' metacognitive skills. Positive results in the study would suggest that we could enhance students' performance simply by trying to affect their self-image as learners. According to Schommer, epistemological beliefs "are likely to influence how students learn, how teachers instruct, and subsequently, how teachers knowingly or unknowingly modify students' epistemological beliefs" (Schommer-Aikins 2004, p. 27). Also, "an appreciation of different beliefs may help teachers pinpoint which beliefs need to be modified for any particular student. It may also help teachers pinpoint students' beliefs that are sophisticated, which lets the teacher know when to provide more advanced learning experiences for students" (p. 23).

To my mind, metacognition has two dimensions – a quantitative and a qualitative one. Already the mere raising of the level of a student's awareness of her learning skills and methods is bound to have a positive effect on them. However, also the quality or nature of this awareness is important: so it is not enough that a student is aware of different factors in learning but it is essential that this awareness is positive by nature: she must have confidence in order to experiment and eventually carry out a task.

Epistemological beliefs

Epistemology is a branch of philosophy which studies the nature of knowledge (Gr. *ἐπιστήμη* – knowledge, science, see. e.g. Hofer 2002, 4). However, within educational science "personal epistemology" refers to the study of a student's conception of knowledge and science. Epistemological beliefs express ideas and attitudes concerning knowledge and learning or knowledge acquisition. The basic assumption then is that knowing is not just a question of *what* one knows but also *how* one knows – one's personal relation to knowledge

plays a central role in learning. Indeed, the importance of metacognition for learning has been noted since the late 1970's (cf. Flavell 1976). In fact, the study of personal epistemology was started by William Perry in the late 1960's (Schommer-Aikins (2004, 19) and the domain has its roots in Jean Piaget's genetic epistemology (Tang 2010). Piaget proposed a genetic and constructivist approach to knowledge and learning. Most importantly, he studied the different stages in the cognitive development of children in relation to different sciences, mathematics and physics in particular. Piaget's relevance for the research of personal epistemology and the present study will be discussed more below. (See Hofer 2002.)

2 Theoretical background

The Multidimensional Model of Personal Epistemology

Perry (1968) studied students' epistemological beliefs from a developmental point of view, suggesting that the development of a person's epistemological beliefs progresses through certain stages. However, Schommer (1990) has argued for a multidimensional model, where epistemological beliefs do not simply mirror a person's cognitive development unidimensionally, but personal epistemology has several dimensions, which are more or less independent. She has proposed five dimensions of epistemological beliefs, originally formulated as the "structure, certainty, and the source of knowledge, and the control and speed of knowledge acquisition" (Schommer 1990). In the present study these dimensions are referred to as 1) simplicity/complexity, 2) certainty/tentativeness, 3) reliance of authority/criticality, 4) impossibility/possibility of learning to learn 5) quickeness/effort of learning.

The Piagetian framework

Although Schommer criticizes the Perryan framework for seeing personal epistemology as a unidimensional refelction of cognitive development, it does not imply that she would deny the link between cognitive development and personal epistemology altogether. Indeed, the main difference from the Perryan viewpoint is that "sophisticated" personal epistemology can take a variety of forms in the five different dimensions, while there should be some correlation between the dimensions.

In studies of personal epistemology including the present one the model of cognitive development is usually adopted from Jean Piaget's work. Piaget introduced the framework of genetic epistemology with its four main stages: 1) the sensorimotor stage (0-2 yrs); 2) the preoperational stage (2-7 yrs); 3) the concrete operational stage (7-11 yrs) and 4) formal operational stage (11-16 yrs and older) (Piaget 1963; Wadsworth 2004). The respondents in the present study were upper secondary school students from 16 to 21 years, and thus in the operational stage in the Piagetian framework.

Purpose of the Present Study

Studies on epistemological beliefs have not been carried out in Finland previously. Thus, it is interesting to see if Schommer's predictions hold for Finnish students, or if students' epistemological beliefs might express national tendencies. Furthermore, given that Finnish students have performed well in the PISA studies, it might be worthwhile to consider if their epistemological beliefs could be relevant in this respect. Naturally, this would require a comparative analysis between students from different countries, which lies beyond the scope of the present study.

3 Methodology

Sample

The sample consisted of 136 upper secondary school students, of which 77 (57%) were female and 59 (43%) male. The study was carried out in two Helsinki-based schools: Etu-Töölö Upper Secondary School and Kulosaari Upper Secondary School.

Materials

The booklet was comprised of two parts: a questionnaire and a formal operations test. The students first completed the formal operations test and then proceeded to the questionnaire, as the formal operations test required a greater intellectual effort than the questionnaire.

An Epistemological Questionnaire

The questionnaire was very close to the one introduced by Schommer (1990) and it comprised 62 items of which altogether 35 were included in the analysis (cf. list below). Students indicated the degree to which they agreed or disagreed with the statements using a 5-point Likert-type scale. The questionnaire was based on five hypothised epistemological beliefs formulated originally by Schommer (1990):

(a) "Knowledge is simple rather than complex" (Simplicity of knowledge, 19 items; α[1] = .602),
(b) "Knowledge is certain rather than tentative" (Certainty of knowledge , 6 items; α = .599),
(c) Knowledge is handed down by authority rather than derived from reason" (Reliance on authority, 4 items; α = .623),
(d) "The ability to learn is innate rather than acquired" (Innateness of ability to learn, 6 items; α = .434*), and
(e) "Learning is quick or not at all" (Quickness of learning, 6 items; α = .558).

As one can see, the epistemological beliefs formulated by Schommer are the *opposite* of what one would expect from a motivated and confident student. Thus, broadly speaking the scores below 3 indicate a conception of knowledge as complex, open to critique, tentative, developing, and requiring an effort (i.e. the Schommerian "sophisticated epistemological beliefs"). Accordingly, scores *above* 3 indicate a conception of knowledge as simple, based on authority, certain and acquired through an innate ability, quickly (the "unsophisticated" outlook). However, one should bear in mind that according to Schommer, these aspects are primarily *independent* dimensions of epistemological beliefs, not expressions of a single, uniform attitude (Schommer 1990, p. 500).

Formal Operations Test and Self-Beliefs

The students also completed an exercise testing their level of formal operations or scientific

[1] 'α' refers to Cronbach's Alpha, an indicator of reliability. Usually, values > .6 are considered reliable and < .6 unreliable.

reasoning. The test was designed by Jarkko Hautamäki and it measures the mastery of the control of variables in the context of Formula 1 lap times (cf. Hautamäki 2014). More precisely, they were supposed to realize that one can measure a variable (e.g. the influence of the tires) by isolating it i.e. fixing all the other variables. The students were divided into three groups according to their score: 1) 0-3 points (n=32), 2) 4-5 points (n=73), 3) 6-10 points (n=30) (Total n=135).

The test part also comprised a section of three questions concerning the students' thoughts about the test: whether it was difficult, interesting and how well the students thought they had performed in the test. The students indicated their view using a 7-point Likert-type scale.

4 Results

The Status of Epistemic Belief Dimensions among Upper Secondary School Students

As was stated above, four of the five epistemological belief variables were reliable, one of the original variables thus being unreliable (4. Cannot lean to learn). The scores for the reliable variables centred around the mean score 3. On average, the students were undecided as to the simplicity of knowledge (1), while they were inclined to endorse the certainty of knowledge (2) and reliance on authority (3), but also acknowledged that learning requires an effort (5).

TABLE 1.1

Epistemological Belief Variables	N	Minimum	Maximum	Mean	SD
1. Simplicity of knowledge	136	2,05	4,68	3,04	,37
2. Certainty of knowledge	135	1,33	6,50	2,80	,67
3.Reliance on authority	136	1,25	9,00	2,44	,76
4. Cannot learn to learn*	136	1,00	9,00	2,23	,82
5. Quickness of learning	136	1,60	9,00	3,38	,64

*Unreliable

Reliance on authority/criticality (3) and quickness/effort of learning (5) were the variables that correlated the most with the other variables (mean for variable 3: .52; for variable 5: .53).

TABLE 1.2

2. Certainty	,579***			
3.Authority	,393***	,445***		
4. Cannot	,212*	,392***	,604***	
5. Quickness	,516***	,477***	,629***	,500***

- p. < .05

** p < .01

*** p < .001

There were no great differences of beliefs based on gender, but on average female students were more inclined to endorse the ideas expressed by the questionnaire items (i.e. *un*sophisticated views in Schommer's terms). However, the standard deviation among females was also greater than among male students. This again could be due to the relatively great proportion of female students (57%).

TABLE 1.3

Epistemological Belief Variables	Gender	N	Mean	SD	Std. Error Mean
1.Simplicity of knowledge	Female	77	3,04	,40	,05
	Male	59	3,03	,33	,04
2. Certainty of knowledge	Female	76	2,87	,71	,08
	Male	59	2,70	,60	,08
3. Reliance on authority	Female	77	2,49	,90	,10
	Male	59	2,39	,51	,07
5. Quickness of learning	Female	77	3,48	,78	,09
	Male	59	3,25	,38	,05

However, for each belief, both females and males were inclined in the same way, be it endorsing or rejecting the belief in question. This could also be because females were on average more inclined to react positively to the items, although reversed items were also included in the questionnaire.

Students' Level of Formal Operations

The students also completed formal operations test designed by Hautamäki (1989). Here also, the results centred close to the mean score 5 (see Table 2.1).

TABLE 2.1

Formal operations test score	N	Minimum	Maximum	Mean	SD
Overall	136	,00	10,00	4,9191	2,34775

TABLE 2.2

	Gender	N	Mean	SD	Std. Error Mean
Formal operations test score	Female	77	4,7532	2,30649	,26285
	Male	59	5,1356	2,40300	,31284
Average mark (Finnish, Mathematics, 1st Foreign language)	Female	74	7,7050	,91518	,10639
	Male	59	7,4718	,78183	,10179
Mathematics mark	Female	73	7,08	1,561	,183
	Male	58	7,07	1,400	,184

Note: the variation in the number of respondents is due to missing data.

Thus, male students performed better in the test, their mean score being 5,14 out of 10, while the mean score for female students was 4,75 out of 10. According to Hautamäki (2014), gender should not affect performance in the test, but in this case the Formula 1 theme could explain male students' better performance, as on average female students had equal or better academic success. Namely, a poor performance in the test may be due to a lack of interest or a feeling of detachment regarding the subject matter, as the unfamiliarity of the subject matter may divert attention away from the logical structure of the test.

Based on the results in the formal operations test, the students were divided into three different groups, 1 (scores 0-3, n=32), 2 (scores 4-5, n=73) and 3 (scores 6-10, n=30), representing respectively 24%, 54% and 22% of the respondents (see Table 2.3).

TABLE 2.3 Frequency of scores:

Score	Frequency	Percent	Valid Percent	Cumulative Percent
0	3	2,2	2,2	2,2
1	5	3,7	3,7	5,9
2	11	8,1	8,1	14,0
3	13	9,6	9,6	23,5
4	22	16,2	16,2	39,7
5	51	37,5	37,5	77,2
6	3	2,2	2,2	79,4
7	7	5,1	5,1	84,6
8	7	5,1	5,1	89,7
9	3	2,2	2,2	91,9
10	11	8,1	8,1	100,0
Total	136	100,0	100,0	

Self-beliefs

After the formal operations test, the students answered three questions concerning the test and their performance. The self-beliefs correlated strongly with the level of formal operations (see Table 2.4).

TABLE 2.4.1 Correlation matrix for self-beliefs, average mark and the level of formal operation test score according to developmental stages 1-3:

	Self-beliefs	Average	Level of
AM	,165		
LFO	,320 ***	,173 *	

- p. < .05

** p < .01

*** p < .001

TABLE 2.4.2 Correlation matrix for self-beliefs, average mark and formal operation test results from 1 to 10:

	Self-beliefs	Average	Formal
AM	,165		
FOS	,345 ***	,261 **	

- p. < .05

** p < .01

*** p < .001

Correlations Between Epistemological Beliefs and the Level of Formal Operations

As we have seen, four of the variables had sufficient reliability:

1) "Knowledge is simple rather than complex";

2) “Knowledge is certain rather than tentative";

3) "Knowledge is handed down by authority rather than derived from reason" and

5) "Learning is quick or not at all"

Of these, three variables (1,2 and 5) were found to manifest statistically significant differences (sig. < .05) in relation to the formal operations test, 1. Simplicity, 2. Certainty, 5. Quickness. In other words, these three variables were found to predict the students’ level of formal operations. Namely, the students in group 3 had a lower mean in these three categories, meaning that they entertained more sophisticated epistemological beliefs in these respects.

Table 3.1 Mean Scores of Groups 1, 2 and 3 on the Epistemological Belief Variables

Epistemological Belief Variables	Group 1 (n=32)	Group 2 (n=73)	Group 3 (n=30)	Overall (n=135)
1. Simplicity of knowledge				
Mean	3,06a	3,10a	2,86b	3,04
SD	0,29	0,38	0,37	0,37
2. Certainty of knowledge				
Mean	2,81a	2,90b	2,54a	2,80
SD	0,51	0,76	0,51	0,67
3. Reliance on authority				
Mean	2,41a	2,51a	2,32a	2,44
SD	0,60	0,90	0,50	0,76
5. Quickness of learning				
Mean	3,35a	3,51b	3,13a	3,39
SD	0,40	0,76	0,47	0,65

Higher scores indicate an endorsement of the idea associated with the variable; the midpoint of the scale is 3.0. Means in the same row that do not share subscripts (a or b) differ at the $p < .05$ level.

TABLE 3.2 Univariate Effects for Level of Formal Operation

Dependent Variable	*df*	*df* error	F	FO Group	Means	SD
1. Simplicity of knowledge	2	132	4,50	1	3,06	,29
				2	3,10	,38
				3	2,86	,37
2. Certainty of knowledge	2	132	3,15	1	2,81	,51
				2	2,90	,76
				3	2,54	,51
3.Reliance on authority	2	132	,76	1	2,41	,60
				2	2,51	,90
				3	2,32	,50
4. Cannot learn to learn*	2	132	,38	1	2,14	,59
				2	2,29	,95
				3	2,23	,67
5. Quickness of learning	2	132	3,90	1	3,35	,40
				2	3,50	,76
				3	3,13	,47

TABLE 3.3 Univariate Effects for Gender

Dependent Variable	*df*	*df* error	F	Gender	Means	SD
1. Simplicity of knowledge	1	133	8002,14	Female	3,04	,40
				Male	3,03	,33
2. Certainty of knowledge	1	133	2000,99	Female	2,87	,71
				Male	2,70	,60
3.Reliance on authority	1	133	1143,89	Female	2,49	,90
				Male	2,39	,51
4. Cannot learn to learn*	1	133	839,84	Female	2,17	,97
				Male	2,31	,57
5. Quickness of learning	1	133	3175,53	Female	3,48	,78
				Male	3,25	,38

For these three variables, the group that had the highest level of formal operations (Group 3) also had the lowest mean, i.e. higher epistemological sophistication according to Schommer-Aikins's model. More precisely, the students in group 3 were the most inclined to regard knowledge as complex (1), tentative as opposed to being certain (2) and as requiring an effort (5). However, these differences should be further qualified in two ways. First, in the case of variables *2)* (knowledge is tentative, not certain) *5)* (learning requires an effort/learning is quick), the differences among the groups are relative, as the means are on the same side of 3. Second, in the case of variable *5)* (knowledge requires an effort/learning is quick), all groups including group 3 were inclined to consider learning more a question of quick intuition than of strenuous effort. So to be precise, group 3 was not so much inclined to regard learning as requiring an effort as the *least* inclined to consider it a matter of quick intuition.

Perhaps surprisingly, it should also be noted that the students in Group 1, who had the lowest level in formal operations had a lower mean than group 2. Thus, although sophisticated epistemic beliefs predict a high level of formal operations, unsophisticated views do not unequivocally predict the lowest level of formal operations, as the students with the lowest level of formal operations (group 1) were less inclined towards unsophisticated views than group 2. Still, the results indicate that a sophisticated mind-set as described above is associated with a high level of formal operations.

5 Discussion

Epistemological Beliefs in Relation to the Level of Formal Operations

The results of the present study indicate that epistemological beliefs are relevant in relation to the level of formal operations. Three of the five variables that were used as measures showed significant differences between the different level groups. These variables were simplicity/complexity of knowledge (1), certainty/tentativeness of knowledge (2), quick learning/effort (5). In all of these cases, inclination toward the latter poles of the variables predicted a higher stage of cognitive development. In relation to the simplicity/complexity variable, a similar result was obtained by Bird (2005).

The study seems to indicate that an incremental view of knowledge is associated with a high level of formal operations as well as academic success. In this sense the fifth variable "learning is quick/requires an effort" would seem to summarize the three variables: the complexity and tentative nature of knowledge would seem to imply the complex and tentative or incremental nature of *learning*, – that it requires time and effort. Indeed, it was also the one with which the other variables correlated the most (see. Table). However, as was noted in the previous section, the inclination of students with a high level of formal operations towards the view of learning as requiring an effort was only relative in comparison with the students with a lower level of formal operations. In absolute terms, they were on average slightly more inclined towards the view that one either learns at once or not at all.

At present, I would argue that epistemological beliefs are still more the product of the cognitive level than the other way round. Namely, it seems intuitive that a student can develop sophisticated epistemological views by effectively learning new skills and acquiring new knowledge, but it does not seem possible that she could gain new skills and knowledge simply by changing her opinions. Still, it would seem plausible that even if one cannot dispense with the hard work of learning, there is some reciprocity between the epistemological beliefs and cognitive abilities and performance. It could be helpful to see epistemological beliefs not as important in themselves but as expressions of an intellectual

orientation.

By increasing the students' awareness of themselves as learners the teacher can transfer some of her responsibility to the students, as they can themselves try and see which learning methods work best for them. This is in tune with another contemporary trend of promoting the self-directedness of learning – we learn best when we are active ourselves.

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