University students' epistemic profiles, conceptions of learning, and academic performance

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Abstract

University students' epistemic beliefs may have practical consequences for studying and success in higher education. Such beliefs constitute epistemic theories that may empirically manifest themselves as epistemic profiles. This study examined university students' epistemic profiles and their relations to conceptions of learning, age, gender, discipline, and academic achievement. The participants were 1515 students from five faculties who completed questionnaires about epistemic beliefs, including a subsample who also completed a questionnaire that included conceptions of learning. We measured epistemic beliefs: reflective learning, collaborative knowledge-building, valuing metacognition, certain knowledge, and practical value. First, we analyzed structural validity by using confirmatory factor analysis. Second, we conducted latent profile analysis that revealed three epistemic profiles: *Pragmatic* (49%), *reflective-collaborative* (26%) and *fact-oriented* (25%). Then, we compared the conceptions of learning across the profiles as well as demographic information, credits, and grades. The profiles' conceptions of learning varied: The *reflective-collaborative* group scored high on conception of learning named "construction of knowledge." Its members were more likely to be females, teachers, and mature students, and they had the highest academic achievement. The *fact-oriented* group (mostly engineering/science students) scored highest on "intake of knowledge." The *pragmatic* group scored highest on "use of knowledge:" During the second year, their academic achievement improved. In sum, the epistemic profiles were closely related to conceptions of learning and also associated with academic achievement.

Keywords Epistemic beliefs · Epistemic profiles · Epistemic cognition · Approaches to learning · Conceptions of learning · Academic performance · Academic achievement · Cluster analysis · Latent profile analysis · Confirmatory factor analysis · University students · Teacher education · Engineering education · Higher education

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Introduction

Students' beliefs about knowledge and knowing may manifest themselves as theories that color the way in which they approach various learning tasks, monitor their knowledge, seek information, and evaluate its relevance (Greene et al. 2016; Lonka and Lindblom-Ylänne 1996; Schommer 1993; Vermunt 1998). Such epistemic theories have been referred to as "personal epistemologies" (Hofer and Pintrich 1997; Hofer 2000, 2001). The present article looks at the complex relations among epistemic theories, conceptions of learning, and academic achievement in the context of higher education.

Recently, a new inclusive umbrella term *epistemic cognition* has been introduced (Hofer 2016). It is not only about beliefs or theories, but also about how knowledge is defined, acquired, and used (e.g., Hofer 2016; Kitchener 1983; Kuhn 1999; Greene et al. 2016). Within this vocabulary, *epistemic beliefs* refer to beliefs about knowledge and the processes of knowing that constitute more or less coherent *epistemic theories* (Hofer 2016; Muis et al. 2016) as an essential part of epistemic cognition.

Originally, Kitchener (1983) came up with the term 'epistemic cognition' when she analyzed the cognitive processes that people used when the problem at hand was complex, was open-ended, and involved contradictory evidence or opinions. Typical of such open-ended or ill-defined problems is that there are no clear-cut correct answers or a reasonable consensus within the respective expert communities about what constitutes an acceptable solution (Lonka 1997). Kitchener defined three levels of cognitive processing when dealing with such problems: (1) *cognitive* (reading, solving problems etc.), (2) *metacognitive*, during which individuals monitor their progress when engaged in such cognitive activities, and (3) *epistemic cognition*, during which individuals reflect on the limits of their knowing, the certainty of knowing, and the criteria of knowing. According to Hofer (2016), the prior understandings of cognition and metacognition did not account for the kinds of mental processes involved in epistemic cognition referring to critical thinking as well as looking at the limits, certainty, and criteria for knowing.

In the present paper, we operationalize epistemic theories as epistemic profiles by clustering the students based on the epistemic beliefs they express. This is done by using a person-oriented approach, specifically, latent profile analysis (see e.g., Vermunt and Magidson 2002). The latent profiles, based on beliefs, are then interpreted to reflect epistemic theories shared by a certain group of university students. In our previous studies, we have found this person-oriented strategy fruitful in understanding how undergraduate students approach their studies in various disciplines (e.g., en et al. 2017).

The present study thus looks at the epistemic beliefs that constitute the epistemic theories (empirically manifested as profiles) of university students. Our interest is in how epistemic theories are related to students' ideas of learning and whether they have any bearing on their academic progress in five different disciplines. In the present paper, we do not directly look at the processes of epistemic cognition, as this is an umbrella term that covers both beliefs and actions: Instead, we focus on the belief level.

On the development and variation of epistemic beliefs

The first wave of research on epistemic beliefs (or personal epistemologies) started with qualitative studies, and the early models were developmental in nature (Hofer 2016). In his seminal work, Perry (1970) described the epistemological development of college students: At

the beginning of their studies, students saw knowledge as an unorganized set of discrete and absolute truths (dualist orientation), but this conception gradually transformed through relativistic ideas, in which all viewpoints were merely "opinions," and further into seeing knowledge as an array of interpreted and integrated positions (see also Hofer and Pintrich 1997).

The phases of epistemic development have been described as three levels of beliefs: (1) Absolutism or dualism, (2) multiplism or relativism, and (3) evaluatism or integrated thought (Kuhn and Weinstock 2002). Increasingly relativistic and integrated ideas of knowledge tend to develop during long-term university studies (e.g., Baxter Magolda 1992; Hofer 2004b; Perry 1970). Such epistemic change rarely happens over a short period of time (Hofer 2001).

The second wave of research on epistemic beliefs intended to quantify the phenomenon by using Likert-type questionnaires. Mixed methods were also used to, for instance, look at how beliefs were related to study activities. It appeared that epistemic beliefs did play a role in how students approached various learning tasks and thus played a role in students' metacognition. Already, Ryan's (1984) study showed that "dualists" often reported knowledge standards (how much one knows), whereas students classified as "relativists" more often reported comprehension standards (how much one understands) when evaluating their learning from text. Ryan further showed that students reporting the use of comprehension criteria earned better grades in a psychology course. Lonka and Lindblom-Ylänne (1996) later replicated this relation between epistemic beliefs and criteria for comprehension among students in medicine and psychology: In their study, epistemic beliefs were also related to preferred study strategies: "Relativists" significantly more often suggested elaborative study strategies than "dualists." Tsai and Liu (2005) summarized research on science learning and concluded that the more students see scientific knowledge as being constructed by scientists (a relativist view), the more likely they are to employ meaningful strategies in science learning. In sum, epistemic beliefs may have practical consequences for how students act. Epistemic beliefs and theories are an essential part of epistemic cognition, that is, how knowledge is acquired and used (Greene et al. 2016).

Multidimensional models

Multidimensionality in epistemic beliefs was introduced by Schommer (1990, 1993), who proposed that epistemic beliefs constitute belief systems that may or may not develop in a synchronized way. She used Likert-type questions in various dimensions of beliefs. Her measures focused only on dualist dimensions and included conceptions of learning: (1) *Innate ability*, when students believed the ability to learn is predetermined, (2) *quick learning* indicating that learning occurs rapidly or not at all, (3) *simple knowledge*, a belief that knowledge can be described as isolated facts, and (4) *certain knowledge,* seeing knowledge as unchanging. Later, Schommer-Aikins (2011) theorized about more complex epistemic beliefs that were related to cognitive flexibility, such as seeing knowledge as tentative, gradual learning, or complex knowledge that could encourage learners to resist premature closure and make them search for more options, sources, or viewpoints in order to solve complex problems.

In other multidimensional models of epistemic beliefs, separate beliefs constituted intuitive epistemic theories. Hofer and Pintrich (1997); see also Hofer 2004a) were critical of mixing conceptions of learning with epistemic beliefs. They proposed a model that constituted four dimensions: *Certainty of knowledge* reflected the willingness to seek certain and fixed facts, in contrast to tentative and evolving knowledge and *simplicity of knowledge*, referring to seeing knowledge as discrete and simple facts instead of relative, contingent, contextual, or interrelated ideas. The other two beliefs were about knowing: *Source of knowledge* refers to the locus

of knowledge that may originate outside the self, given by the authorities who transmit it, or something actively constructed by the learner. *Justification of knowing* refers to beliefs of how people justify their beliefs and how they evaluate their own or other people's knowledge.

Greene et al. (2008) pointed out that from the philosophical point of view, only justification is really related to classic philosophical epistemology that does not refer to whether knowledge is simple or certain but rather to the kinds of claims that can be justified. "Epistemological theory" implicates a metatheory about epistemic beliefs, as philosophers have pointed out (Hofer 2016). In the present article, we therefore talk about "epistemic beliefs" or "epistemic theories" instead of "epistemologies." The epistemic profiles, consisting of beliefs, are interpreted to reflect students' more or less coherent epistemic theories.

Are epistemic beliefs general or based on discipline or domain?

There have been debates on whether epistemic beliefs are general, based on academic context (discipline), domain-specific, or even topic-specific. These levels of study are somewhat difficult to define. Schommer and Walker (1995) suggested domain-generality, whereas Muis et al. (2006) supported domain-specificity.

Students may share the same beliefs in a certain discipline, for instance, natural science students tend to be more absolutist or dualistic in their beliefs than humanities students (Nieminen 2011). This is between-student variation. Hofer (2000) indicated within-student variation in different fields of study by showing that first-year college students in an introductory psychology course saw knowledge in science as more certain and unchanging than that in psychology. Authority and expertise were more often seen as the source of knowledge in science than in psychology, and truth was more often seen as attainable in science than in psychology.

Hofer (2016) called for more precision and clarity on the relations among general-, discipline-, or topic-related beliefs. Lonka and Lindblom-Ylänne (1996) showed that the general level of dualism was higher among medical students than among psychology students, but in both disciplines, the advanced students expressed less dualist views than the novices. In their study, both discipline and level of studies appeared to be important. Merk et al. (2018) recently showed a reciprocal influence between topic-specific and more general epistemic beliefs. The current consensus is that epistemic beliefs have a dual nature: They are both domain-general and domain-specific (Hofer 2016; Mason 2016). We wanted to see, how epistemic theories varied across disciplines in higher education.

Conceptions of learning meet epistemic beliefs

The aims of university students vary; they may have different goals for knowledge, understanding or seeking truth (Buehl and Fives 2016). Some students want to reflect on their own thinking and study materials or create knowledge collaboratively, while others prefer receiving directly applicable, certain, and simple knowledge from their teacher (Lonka et al. 2008). Our interest is in how closely such beliefs of knowledge and learning are related to each other and whether they form systematic theories.

From the point of philosophy, conceptions of human knowledge and learning are not only epistemological; they are also ontological, as they involve assumptions about the known world and the knowing person (Packer and Goicoechea 2000). Lonka et al. (1996) proposed that students' definitions of learning provide a window for looking at their personal epistemologies, because conceptions of learning implicitly include conceptions of the origin and nature of

knowledge. If we come to learn something, this inevitably refers to a process of how knowing and learning happens and what the origin of knowledge is.

Initially, Hofer and Pintrich (1997) as well as Hofer (2001) suggested that personal epistemologies should be separated from conceptions of learning, whereas Schommer (1990) suggested that personal epistemology could be seen as a collection of beliefs about knowledge and learning. Hammer and Elby (2002) also suggested that epistemic beliefs include ideas on both knowledge and learning. Many researchers looked at conceptions of learning and epistemic beliefs simultaneously using qualitative categories (e.g., Lonka et al. 1996; Marton et al. 1993; Säljö 1979; Vermunt 1996). Conceptions of learning were classified in increasingly complex categories, starting from memorizing and knowledge acquisition, then applying knowledge, understanding, or making sense of knowledge, and, further, and finally seeing knowledge from new perspectives or changing as a person or creating new knowledge. In qualitative studies, conceptions of learning and knowledge often merge. For instance, in her empirical study, Hofer (2004b) showed that epistemic theories and approaches to learning were indeed closely linked. In the context of school science, Shubert and Meredith (2015) used the term "pragmatic epistemology" to combine students' ideas about knowledge, knowing and learning in their own academic practices.

Marton and Säljö (1976) originally identified deep and surface approaches to learning as different strategies: In general, the surface approach referred to an intention that was extrinsic to the real purpose of the learning task, aiming to memorize or invest minimal time and effort, whereas the deep approach was based on the strategy of maximizing understanding (Biggs 1985). A wave of quantitative studies followed to explore approaches to learning: Entwistle and Ramsden (1983) introduced the *Approaches to Studying Inventory* (ASI; later ASSIST, Tait et al. 1998), Biggs (1985) constructed the *Study Process Questionnaire* (SPQ), and Vermunt (1998, 2020) and colleagues developed the *Inventory of Learning patterns of Students (ILS)* to measure students' learning patterns.

The ILS contains 16 scales to measure four learning components: processing strategies, regulation strategies, conceptions of learning, and learning orientations. The ILS includes three scales to measure the conceptions of learning that are students' views on (good) learning and teaching. They measure the degree to which students view learning as the intake of knowledge, the construction of knowledge, and the use of knowledge. The final learning component of the ILS are students' learning orientations, representing their motives, aims, goals, and worries with regard to their studies: Personal interest, certificate orientation, self-test orientation, vocational orientation and ambivalence (for a review, see Vermunt and Donche 2017).

Vermunt and Vermetten (2004) conceive a learning pattern as a coherent whole of processing and regulation strategies that students usually employ, their conception of learning, and their learning orientation, a whole that is characteristic for them during a certain period of time. *A reproduction-directed learning pattern* involves both surface strategies, a conception of learning that emphasizes the intake of knowledge, as well as certificate and self-test learning orientations. *Meaning-directed learning* is typified by the use of deep processing strategies as well as construction of knowledge as learning conception, and personal interest as learning orientation. Students who adopt an *application-directed learning* pattern often use concrete processing strategies, attach a great deal of value to using knowledge, and are vocationally motivated to learn (e.g. Vermunt and Donche 2017). Vermunt (1998) found the application-directed learning pattern to be especially prevalent among older students with work experience. Smith et al. (2007) found that application-directed learning dominated among pharmacy students in Australia and remained stable throughout the study.

Lonka and Lindblom-Ylänne (1996) also found reproduction and meaning orientations as well as a professional orientation, resembling application orientation. They combined ILS measures with ASI as well as with measures of epistemic beliefs and conceptions of learning. They found that advanced medical students typically showed a strong professional orientation. Lonka and Lindblom-Ylänne (1996) showed that the surface approach, dualistic epistemic beliefs, and the ILS conception of learning "intake of knowledge" all loaded on reproduction orientation factor, the deep approach and "construction of knowledge" loaded on meaning orientation factor, whereas the professional orientation factor was separate from these two with a strong loading by "use of knowledge."

Lonka et al. (2004) proposed that the conception of the deep approach should also involve collaborative aspects of learning, because the current socio-constructive ways of learning (i.e. problem- and inquiry-based learning) are based on the idea of knowledge as socially created (e.g., Paavola and Hakkarainen 2005; Scardamalia and Bereiter 2006). Lonka et al. (2008) later showed that among medical students, the deep approach to learning, valuing metacognition, reflective learning, and collaborative knowledge-building indeed all loaded on the same factor, whereas belief in certain knowledge, surface approach to learning, and valuing practical knowledge, all loaded on the same factor. Later, a person-oriented approach showed more variation: The epistemic profile of "a reflective professional" emerged, where practical value was related to reflective learning and valuing metacognition (Heiskanen and Lonka 2012).

Research questions

Research on epistemic beliefs in higher education is rather complex itself. Adding the vast literature on research on approaches to learning (and conceptions of learning) complicates the question even more. By using a person-oriented strategy, we wanted to test our theoretical ideas and deepen our understanding of the relations between these two fields of study. Current understanding is that conceptions of knowledge and learning are intertwined, and we wanted to further test this assumption. There is also a need to further validate survey instruments that capture complex epistemic beliefs in higher education (Richardson 2013).

We wanted to combine the various dimensions of epistemic theories and investigated their simultaneous relation to conceptions of learning and academic achievement. A variable-oriented approach describes overall relations among variables, behind which differently functioning sub-groups of individuals and the specific relations between variables may be hidden. Instead, we adopted a person-oriented approach (see e.g., Bergman and Magnusson 1997) in order to investigate the associations between various dimensions of students' epistemic theories and their combined effect on academic achievement and conceptions of learning. Person-oriented methods represent a cluster analytical approach, one in which students with a similar profile in a set of variables can be classified as one type (e.g., Vermunt and Magidson 2002).

Our first research question was "Does our instrument comprise a five-factor structure of epistemic beliefs consisting of (1) reflective learning, (2) collaborative knowledge-building, (3) valuing metacognition, (4) certain knowledge, and (5) practical value in this population?" Based on previous research, we expected the goodness-of-fit indices to support a five-factor model (Lonka et al. 2008; Vedenpää and Lonka 2014).

Our second research question was "What kinds of epistemic theories can a person-oriented approach find?" The person-oriented analysis can reveal groups of students who share the same epistemic beliefs that form their shared epistemic theory. We expected variation, and similar patterns to those in our previous studies using both variable- and person-oriented approaches

(Heiskanen and Lonka 2012; Lonka et al. 2008). We expected to find three to four groups of students. Because the participants were mainly undergraduates, we expected that the profiles would be dominated with beliefs in certain knowledge, rather than beliefs of metacognition, reflection, and collaborative knowledge-building. Because we were dealing with academic professions (e.g. future teachers and lawyers), we also expected practical ideas of knowledge to dominate.

Our third question was "How are epistemic theories related to Vermunt's conceptions of learning (1996, 1998)?" We expected the epistemic profiles emphasizing metacognition, collaborative knowledge-building and reflection to be related to the "construction of knowledge" conception of learning, valuing practical knowledge to be related to "use of knowledge" and profiles valuing certain knowledge to be related to the view of learning as "intake of knowledge."

Our fourth research question was "Do epistemic profiles differ in terms of academic achievement, discipline or age?" Based on previous studies (Lonka and Lindblom-Ylänne 1996; Tsai and Liu 2005), we expected younger students and students in science and engineering to value certain knowledge more than mature students and students of law, theology, and teacher education. As within the latter domains the phenomena (or problems) are more open-ended in nature, we expected less beliefs in certain knowledge and more collaborative or constructivist beliefs.

Method

Context and procedure

In Finland, it is very difficult to get accepted at universities, and the number of applicants is many times higher than the intake. It is especially difficult to be accepted to study law or teacher education (class teacher program). Most students in the present study were highly selected university students, who were accepted to a combined BA/MA track. A bachelor's degree takes approximately 3 years (180 European Credit Transfer and Accumulation System (ECTS) credits), and a master's degree about 2 years (120 ECTS credits) to complete.

We collected self-report questionnaires during mass courses at the faculties of two major universities in Finland. The students either completed the questionnaire during a lecture or received it via email. For ethical reasons, the participation was fully voluntary, and all participants signed an informed consent form which included consent to use and merge student register data with the questionnaire data.

Participants

Original sample

The participants in the original sample were 1515 Finnish students studying in the faculty of law ($n = 168$), theology ($n = 125$), science ($n = 153$; mainly math, chemistry, and physics students), or educational sciences ($n = 424$; mainly teacher students) at the University of Helsinki or Aalto University ($n = 645$; mainly technology and engineering students). Of the participants, 51% were females and 49% males. The age of the participants varied from 18 to 59 ($M = 25.8$, $SD = 6.5$). Of the participants who reported their starting year ($n = 1334$), 52% were first-year students, 25% were Bachelor's students (second or third year), and 23% were Master's students (fourth year or beyond), thus representing all levels of undergraduate students.

Subsample

We gathered conceptions of learning from only first- and second-year students who were carrying out their basic studies in the above-mentioned faculties ($n = 709$). That is, first- and second-year law ($n = 163$), theology ($n = 119$), science ($n = 129$), teacher ($n = 227$), and engineering ($n = 71$) students were included, representing five different domains. Of these students, 64% were female and 36% male (age ranging from 18 to 58; $M = 24.7$, $SD = 6.8$).

Academic achievement follow-up data

For the final phase of the analyses, we followed-up the students from the subsample in terms of academic achievement from the student register. We gathered the participants' accumulation of credits (ECTS) and the mean of all their grades (GPA) during the academic year when we collected the questionnaire data (current performance) and during the following academic year (students' second or third academic year). Both years, the data were retrieved from the universities' records. Altogether, 565 participants from the subsample (79.7%) gave their student number along with permission to merge the register data with the questionnaire data. We found achievement statistics on current performance for 541 participants (76.3%) and on performance the following year for 476 (67.1%) in the universities' records.

Measures

The self-report questionnaire given to the whole original sample consisted of 15 Likert-type statements based on the MED NORD questionnaire (Lonka et al. 2008), which measures epistemic beliefs: Collaborative knowledge-building, reflective learning, valuing metacognition, certain knowledge, and practical value. Table 1 shows the scales and example items. Participants rated all the statements on a six-point Likert scale (1 = totally disagree, 2 =

Table 1 Scale name, number of items, example item, and Cronbach's alpha of each epistemic belief and conceptions of learning scale

Scale	No. of items	No. of students	Example item	α
Collaborative knowledge-building	4	1515	*In my opinion, it is essential that students generate new ideas and thoughts together.*	.749
Reflective learning	3	1515	*As I study a new topic I often think about new questions, which I try to answer myself.*	.670
Valuing metacognition	2	1515	*Knowing one's own thinking is the major contributor to successful learning.*	.712
Certain knowledge	4	1515	*Scientific knowledge is absolutely certain in nature.*	.812
Practical value	2	1515	*A theory is useful only if it can be applied to real life.*	.642
Intake of knowledge	4	709	*To me, learning is making sure that I can reproduce the facts presented in a course.*	.669
Construction of knowledge	4	709	*If I have difficulty understanding a particular topic, I should consult other books, the internet etc. of my own accord.*	.641
Use of knowledge	4	709	*The things I learn have to be useful for solving practical problems.*	.704

disagree, 3 = partially disagree, 4 = partially agree, 5 = agree, 6 = totally agree). The higher the score, the more the epistemic dimension in question was valued.

For the subsample, we adopted three conceptions of learning scales from the ILS (Vermunt 1998). We took 12 items from the intake of knowledge, construction of knowledge, and use of knowledge scales from this inventory, four for each scale. The items represent views on learning, teaching, and related phenomena. We asked students to indicate the degree to which they agreed with each statement on a five-point Likert scale, varying from (1) "totally disagree" to (5) "totally agree." Table 1 provides examples of items on both epistemic beliefs and conceptions of learning.

Data analyses

To answer the first research question, we analyzed the structural validity of the epistemic beliefs scales using confirmatory factor analysis (CFA). To answer the second research question, using a person-centered approach, we classified the students into homogenous groups with similar profiles (theories) of the epistemic beliefs variables by means of latent profile analysis (LPA). Among the different classification methods, LPA has the advantage that it represents a model-based approach which allows evaluation of the model fit and the comparison of different models with distinct numbers of profiles (Vermunt and Magidson 2002). That is, LPA provides statistical criteria that enable comparison between different models and decision-making regarding the number of underlying profiles. Furthermore, LPA approach allows cases to be classified into profiles using model-based posterior membership probabilities estimated by maximum likelihood (ML) methods and the model can be easily extended to include exogenous variables (e.g., covariates). This allows both classification and profile description to be performed simultaneously using a single uniform ML estimation algorithm and taking into account misclassification biases (Magidson and Vermunt 2002).

To answer the third and fourth research questions and to compare the differences between the profiles in terms of conceptions of learning, academic achievement, and background variables (age, domain, gender), we used an auxiliary Mplus command (Muthén and Muthén 1998–2017). This method has the advantage that it simultaneously takes into account the model-based posterior membership probabilities of LPA (and possible misclassification biases) but does not allow for the auxiliary variable to dramatically change the class membership for individual observations (see Asparouhov and Muthén 2014). With continuous variables, we tested the quality of means across profiles using the BCH procedure, and with categorical variables, we tested probabilities across profiles using the DCAT procedure. With categorical variables (e.g., faculty membership), the probabilities that the auxiliary and DCAT procedure offers are odds ratio, which simply quantifies the strength of the association between A and B and is easy to interpret as it is (e.g., odds ratio value 9.580 means that teacher students are 9.6 times more likely to belong to a certain profile) (see Asparouhov and Muthén 2014).

Results

Confirming the factor structure of epistemic beliefs

The first research question concerned the structural validity of the epistemic beliefs scales and we wanted to confirm the five belief scales of the instrument in this very population. In the CFA model, we allowed all items for each scale to load on the corresponding factor only. Good model fit was

defined as a value above .95 on the Comparative Fit Index (CFI), as a value below .05 on the Root Mean Square Error of Approximation (RMSEA), and as a value below .08 for the Standardized Root Mean Square Residual (SRMR; see, for example, Hu and Bentler 1999). All solutions were generated using the Maximum Likelihood (ML) estimation. The hypothesized CFA model fit the data well ($\chi^2 = 338.77$, $df = 80$, $p = .00$, CFI = .96, RMSEA = .046, SRMR = .034).

Latent profile analysis: epistemic profiles

To answer the second research question, what kinds of epistemic theories could be found, we constructed LPAs using the composite scores of the epistemic belief scales. LPA provides fit indices that enable comparison of different models and decision-making regarding the number of underlying classes. As statistical criteria, we used the Bayesian Information Criterion (BIC and adjusted BIC), and a Vuong-Lo-Mendell-Rubin and Lo-Mendell-Rubin–adjusted likelihood ratio test (VLMR and LMR) for choosing the best-fitting model (Lo et al. 2001). The reasonableness of the latent classes in relation to theory and previous research were also considered criteria for choosing the best-fitting model.

Figure 1 presents the elbow plot of the information criterion (BICs) for the different LPA solutions. The point after which the slope flattens out indicates the optimal model to choose, that is, the optimal number of profiles in the data (Mäkikangas et al. 2018). As illustrated in Fig. 1, all the information criteria clearly decreased between the one- and three-profile solutions, but then remained at the same level¸ thus supporting the three-profile solution. The model with three student profiles also had a clear interpretation, contained profiles with sufficiently large memberships (i.e., > 5% of the cases), and was also favored by the VLMR and LMR ratio tests (see Table 2). Figure 2 shows the three-profile solution.

The first profile was the largest. The most significant variables that differentiated students into this group were the highest values in certain and especially practical knowledge (see Table 3). The profile was named *pragmatic* (49%). The second profile consisted of a clearly smaller group of students who highly valued collaborative knowledge-building as well as metacognition and reflection. This profile clearly had the lowest values in certain knowledge. It was named *reflective-collaborative* (26%). In the third profile, the students were less collaborative and reflective than those in the other two profiles and were between the two profiles in certain knowledge and practical value. They were named *fact-oriented* (25%).
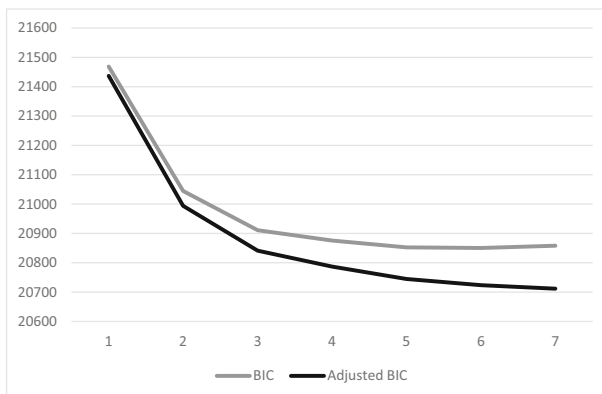

Fig. 1 Elbow plot of information criteria for different profile solutions

Table 2 Information criteria values for different profile solutions in LPAs

Number of profiles	BIC	Adjusted BIC	p_{VLMR}	p_{LMR}	Group sizes
1	21,468.649	21,436.882	–	–	1515
2	21,045.178	20,994.350	0.0000	0.0000	724, 791
3	20,911.173	20,841.285	0.0043	0.0047	377, 392, 746
4	20,875.880	20,786.932	0.0481	0.0513	259, 266, 99, 891
5	20,852.714	20,744.705	0.0248	0.0269	103, 75, 783, 336, 218
6	20,850.702	20,723.633	0.0554	0.0582	79, 408, 792, 307, 19, 210

Note: BIC = Bayesian Information Criterion, adjusted BIC = adjusted Bayesian Information Criterion, p_{VLMR} = Vuong-Lo-Mendell-Rubin likelihood ratio test, p_{LMR} = Lo-Mendell-Rubin–adjusted likelihood ratio test

Epistemic theories and conceptions of learning

The third research question addressed the relation between epistemic profiles and conceptions of learning. Table 4 shows the results of the profile comparisons ($n = 709$ in the subgroup that also responded to questions on conceptions of learning). The *reflective-collaborative* group was the least likely to view learning as "intake of knowledge" and the most likely to score high on the "construction of knowledge" scale. In contrast, the students in *pragmatic* and *fact-oriented* groups were most likely to express "intake of knowledge." The *pragmatic* group also scored high in "use of knowledge," whereas the students in the *fact-oriented group* were the least likely to express "use of knowledge" or "construction of knowledge."

Epistemic profiles in relation to academic achievement, discipline, age, and gender

Research question four addressed the relations between profiles, academic achievement, and demographic information. Table 5 shows the results of profile comparisons in terms of academic achievement ($n = 541$ in first year and $n = 476$ in second year). Regarding current performance, the *reflective-collaborative* group succeeded better in terms of both GPA and ECTS credits than the other two groups and was the only group that achieved the Ministry of Education's goal of 55 credits per academic year. After another academic year, the pattern changed slightly. Both *pragmatic* and *reflective-collaborative* students managed to reach the goal of 55 credits during the second academic year. Furthermore, we only found differences in terms of GPA between the *reflective-collaborative* students and *fact-oriented* students,
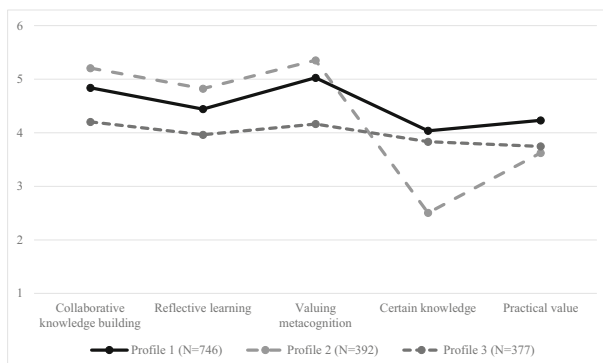
Fig. 2 Three-profile solution based on raw scores

Table 3 Means of grouping variables between epistemic profiles

Variable	Pragmatic, $N = 746$	Reflective, $N = 392$	Fact-oriented, $N = 377$
Collaborative knowledge-building	4.84	5.21	4.20
Reflection	4.44	4.82	3.96
Metacognition	5.03	5.35	4.16
Certain knowledge	4.04	2.50	3.83
Practical value	4.23	3.62	3.75

although the *pragmatic* students also improved their performance in terms of GPA during the second year.

Table 6 shows that older students were more likely to belong to the *reflective-collaborative* profile group than to the other two profiles ($p = .000$). Table 7 shows that male students were less likely to belong to this profile (odds ratio 0.304), but we found no gender differences in the other two profiles. Furthermore, Table 7 shows disciplinary variation: Teacher students were most likely to belong to the *reflective-collaborative* profile group (odds ratio 9.580), whereas almost none of the science (odds ratio 0.019) or engineering students (odds ratio 0.193) belonged to it. Almost none of the law students were in the *pragmatic* profile group, since the majority were either in the *reflective-collaborative* (odds ratio 9.008) or *fact-oriented profile* (odds ratio 6.633). Theology students were equally represented in all the profiles.

Discussion

First, the structural validity of the instrument appeared good. The Cronbach alphas of all the scales were satisfactory, even though we measured some beliefs using only two questions. The intention was to minimize the number of questions and maximize reliability in order to develop brief questionnaires. This instrument can be used as part of more extensive inventories without making them overly long. In the future, we shall look at how these beliefs are related to university students' well-being and study engagement (Ketonen et al. 2017).

The second research question about what kinds of epistemic theories can be found was answered by the LPA results, which revealed *Pragmatic*, *reflective-collaborative*, and *fact-oriented* profiles. This analysis showed that university students' epistemological profiles varied considerably. In all, the cluster solution resembled that of previous research (both variable- and person-oriented) and showed reproductive, meaning-oriented, and application/professional orientations (e.g. Lonka and Lindblom-Ylänne 1996; Vermunt 1998). The new twenty-first century meaning orientation was colored by the idea of collaborative knowledge construction, as suggested by Lonka et al. (2004).

Table 4 Means of conceptions-of-learning variables between epistemic profiles

Variable	Pragmatic, $N = 334$	Reflective, $N = 200$	Fact-oriented, $N = 175$
Intake of knowledge	3.50$_a$	2.64	3.34 $_a$
Construction of knowledge	3.44	3.70	3.01
Use of knowledge	4.00	3.68	3.42

Note: Means within a row sharing the same subscripts are not significantly different at the $p < 0.05$ level

Table 5 Means of academic achievement variables between epistemic profiles

Variable	Pragmatic, $N = 334$	Reflective, $N = 200$	Fact-oriented, $N = 175$
GPA 1st year	3.29$_a$	3.72	3.43 $_a$
GPA 2nd year	3.51 $_{ab}$	3.59 $_a$	3.32 $_b$
ECTS 1st year	52.6 $_a$	62.4	50.0 $_a$
ECTS 2nd year	57.0 $_a$	57.8 $_a$	48.5

Note: Means within a row sharing the same subscripts are not significantly different at the $p < 0.05$ level. First year refers to the year the questionnaire data were gathered in, and second year to the following academic year. GPA ranges from one to five, with one indicating an adequate grade and five indicating excellent performance

The pragmatic group was the largest, which reflected the nature of the population: Most of the participants studied in order to graduate as academic professionals. We think that this may add a new dimension for epistemic cognition research: A strong utility value emerged among the participants (Shubert and Meredith 2015). In the future, elaborating on this kind of pragmatic epistemology may appear fruitful.

Third, it appeared that the conceptions of learning were closely related to epistemic profiles and varied according to these in a logical way. The students who belonged to groups that valued reflection also scored high in "construction of knowledge," whereas "intake of knowledge" was more typical in the fact-oriented groups. The reflective-collaborative profile group did not value "use of knowledge" as much. Thus, we found a clear relation between these different theoretical constructs. Conceptions of knowledge (epistemic beliefs) were indeed closely related to Vermunt's (1998) conceptions of learning.

The fourth research question was about academic achievement and other demographic variables. Academic achievement was best in the reflective-collaborative profile group. Only this group achieved the official target of 55 ECTS during the first year of study. During the second year, the pragmatic students reached the same level. This may be because the typical theoretical, introductory courses did not motivate the pragmatic profile group. Reflective-collaborative profile was related to the best grades. It will be interesting to follow the students further and see how possible epistemic changes and academic achievements develop during their studies. The positive relation between the age of the students and their epistemological beliefs fits well with previous research on the development of epistemologies (e.g., Baxter Magolda 1992), as absolute, fact-oriented beliefs of knowledge were more typical among the youngest students.

The variation among the disciplines was not surprising. Students from more ill-defined disciplines tend to report higher levels of deep approach and lower levels of surface approach than students in disciplines in which it is easier to reach a consensus about "right" and "wrong" answers (Booth et al. 1999; Entwistle 2007; Laird et al. 2008). Such discipline-related variance has also been found in students' epistemic beliefs: Students of natural sciences and engineering tend to believe in certain knowledge more than students in fields such as the humanities and social sciences (Jehng et al. 1993; Kaartinen-Koutaniemi and Lindblom-Ylänne 2008; Paulsen and Wells 1998).

Table 6 Means of age between epistemic profiles

Variable	Pragmatic, $N = 746$	Reflective, $N = 392$	Fact-oriented, $N = 377$
Age	24.9$_a$	28.5	24.8$_a$

Note: Means within a row sharing the same subscripts are not significantly different at the $p < 0.05$ level

Table 7 Odds ratios of gender and discipline between epistemic profiles (Pragmatic as the reference profile)

Variable	Pragmatic, $N = 746$	Reflective, $N = 392$	Fact-oriented, $N = 377$
Gender (1 = female, 2 = male)	1.000$_a$	0.304	1.048$_a$
Discipline			
Teacher education	1.000$_a$	9.580	1.195$_a$
Science	1.000$_a$	0.019	0.922$_a$
Engineering	1.000$_a$	0.193	0.641$_a$
Law	1.000	9.008$_a$	6.633$_a$
Theology	1.000$_a$	0.942$_a$	0.836$_a$

Note: All categorical variables are dummy-coded. Odds ratios within a row sharing the same subscripts are not significantly different at the $p < 0.05$ level

Methodological reflections

There is now an increasing consensus regarding the idea that knowledge and learning are closely intertwined. The present study provided further evidence to support this claim.

Since epistemic cognition is recognized as being increasingly contextual and social in nature (Greene et al. 2016), the research methods used should also change accordingly. We believe that a person-oriented approach may help to identify groups of students who share similar epistemic profiles that may be interpreted as epistemic aims or dispositions that play a role in how well students identify within their own discipline. For instance, think-aloud methods, observations, and stimulated recall interviews could be triangulated with epistemic profiles to see how epistemic cognition is constituted in practice (e.g., Ferguson et al. 2012; Hofer 2016; Sandström et al. 2014; Shubert and Meredith 2015).

Using Likert scales has been criticized partially because they more easily measure beliefs of certain or simple knowledge, whereas source of knowledge and justification of knowledge are harder to quantify (Hofer 2000, 2016). Studies focusing on epistemic cognition and cognitive resources tend to use qualitative methodologies, whereas studies on epistemic beliefs often make use of larger quantitative data sets (Maggioni and Parkinson 2008). This study continued this tradition, even though we were aware of its limitations. We found it important to measure complex epistemic beliefs in ways that are easy to administer.

One limitation of our study was that the results are collected from highly selected Finnish students. The results cannot be generalized to all higher education students. For ethical reasons, the participation was voluntary, which may have caused self-selection bias. Also, some students filled in the questionnaire during lectures, whereas others filled it in an electronic form, depending on the institutional routines of their Faculty. Some of the scales were quite short as in the original questionnaire (Lonka et al. 2008). All scales were, however, acceptably reliable and the CFA results showed structural validity.

Large data sets obviously require the measurement of "sophisticated" epistemic beliefs, which we did in the present study. For instance, Richardson (2013) saw many previous instruments as conceptually limited, because they mainly measured naïve beliefs. We bring some new angles to the discussion on complex epistemic beliefs, since we could measure these dimensions in a reasonably reliable way using only a limited number of questions. Also, contrasting between naïve and sophisticated beliefs may not be fruitful: from the resource point of view the beliefs are not right or wrong themselves, but they may be productively or unproductively put in practice in different contexts (Shubert and Meredith 2015). The beliefs and strategies that are useful at different phases of studying or in different disciplines may vary.

Conclusion

Educational psychology is not always precise when it refers to epistemologies (Muis et al. 2006). Also, different communities of practice have their own ways and reasons for approaching knowledge (Lave and Wenger 1991). Valuing metacognition may indicate an attempt to determine whether one can justify one's beliefs, whereas valuing collaborative knowledge construction may indicate a new, increasingly sociocultural epistemic view. In the present study, we used a person-oriented approach to determine what kinds of epistemic profiles, based on separate epistemic beliefs, were found among university students in five different faculties. Such profiles may be interpreted as theories, aims, or dispositions that are shared by students studying the same discipline, even across all phases of study.

In order to develop interdisciplinary teamwork, it is important to foster epistemic understanding between disciplines. Complex global issues pose increasing challenges for communication among different communities of practice. The present study showed how epistemic theories and aims varied across disciplines. Our concern is that interdisciplinary communication is not only a question of ignorance or lacking knowledge, but also a question of communicating across different epistemic theories.

Social epistemology suggests that society's practices influence what is defined as the truth or acceptable justification (Murphy 2003). Epistemic beliefs or theories are socially shared and contextual in nature (Entwistle 2007). Sociocultural theories emphasize that the origin of knowledge does not lie within an individual mind (Packer and Goicoechea 2000). What counts as "real" varies culturally and changes historically. In recent years, personal epistemologies have indeed turned into social epistemologies (Hofer 2016; Barzilai and Zohar 2016). A person-oriented approach helps to identify groups of students or communities who share the same epistemic theories.

The cognitive aspects of learning, however, can explain only a limited part of student learning, success and well-being. Regulation, motivation, goals, and engagement are also crucial (Efklides 2008; Heikkilä and Lonka 2006; Ketonen et al. 2017). Muis et al. (2015) introduced *epistemic emotions*, such as curiosity and confusion, as important determinants of learning. We demonstrated that study engagement was related to epistemic profiles (Heiskanen and Lonka 2012). The person-oriented approach has also been useful in our studies on study engagement and interest (Ketonen et al. 2017). In our ongoing studies, we shall also examine whether epistemic profiles are related to motivational and emotional experiences during studies. Our longitudinal follow-up studies shall reveal how students' epistemic theories and study engagement develop over the years in different disciplines in higher education.

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