Science & Education (2025) 34:1273–1299
https://doi.org/10.1007/s11191-023-00483-y

ARTICLE

First-Year Teacher Education Students' Epistemological Beliefs About Science and History: Domain-Specific Profiles and Relationships

Erzsébet Korom[1,2] · **Márió Tibor Nagy**[2,3] · **Maja Majkić**[3]

Accepted: 25 October 2023 / Published online: 18 December 2023

Abstract
This study investigates the developmental levels of epistemological beliefs (EBs) about science and history among first-year teacher trainees ($n = 146$) through domain-specific questionnaires. A between-person analysis was used to examine the effect of academic studies and gender differences. Further, we employed a person-centred approach, k-means cluster analysis, to identify EB profiles for both domains. The results show that the impact of academic studies is greater on discipline-specific epistemological beliefs in history than in science, while the effect of gender is not significant in either area. We identified three EB profiles for both domains and found a significant positive correlation between the domain-specific EB profiles. A quarter of student teachers have a sophisticated profile in both science and history. Our research confirms the approach that individuals' domain-specific epistemological beliefs develop in relation to domain-general beliefs. The results, in addition to contributing to a better understanding of the development of epistemological beliefs, also carry important implications for teacher education.

Keywords Epistemological Beliefs · Science · History · Profile Analysis · Domain Differences · Teacher Education Students

1 Introduction

Epistemology is a philosophical discipline concerned with knowledge and its origins, nature and barriers (Hofer & Bendixen, 2012; Hofer & Pintrich, 1997). In recent decades, individuals' epistemological beliefs (EBs) about the nature of knowledge (beliefs

✉ Erzsébet Korom
korom@edpsy.u-szeged.hu

Márió Tibor Nagy
nagy.mario.tibor@edu.u-szeged.hu

Maja Majkić
kmaja6@gmail.com

[1] Department of Learning and Instruction, Institute of Education, University of Szeged, Szeged, Hungary

[2] MTA–SZTE Digital Learning Technologies Research Group, University of Szeged, Szeged, Hungary

[3] Doctoral School of Education, University of Szeged, Szeged, Hungary

about the characteristics of knowledge) and the nature of knowing (beliefs about the process of knowledge acquisition) (Hofer & Pintrich, 1997) have become a prominent research topic among psychologists and educational researchers (Muis et al., 2006).

Findings have highlighted that personal epistemology acts as a mental filter in the knowledge acquisition process as learners interact with new information and its source (Hofer & Bendixen, 2012). Students' epistemological beliefs have an impact on their learning and reasoning processes (King & Kitchener, 2002) and are related to their academic performance (Greene et al., 2018; Schommer, 1993; Stoel et al., 2017; Trautwein & Lüdtke, 2007) and learning motivation (Buehl & Alexander, 2005; Guo et al, 2021). The nature and development of epistemological beliefs play an important role in teacher education since student teachers' epistemological beliefs can determine how they approach and evaluate or ignore the information presented in their studies (Fives & Buehl, 2008). It also influences their teaching strategies and their role as teachers in communicating academic knowledge (Çam, 2015; Green & Hood, 2013; Kutluca & Mercan, 2022; Maggioni et al., 2009; Miguel-Revilla et al., 2021; Peffer & Ramezani, 2019; Saylan et al., 2016) and how they knowingly or unknowingly modify their students' epistemological beliefs (Schommer-Aikins, 2004).

An important question in epistemological research is whether epistemological beliefs are domain-general or specific. In the context of teacher education, this arises in terms of whether the epistemic beliefs of student teachers are similar across disciplines or whether the domain-specific beliefs of future teachers studying in that discipline are more sophisticated. Preliminary research suggests that epistemological views are both domain-general and domain-specific (e.g. Merk et al., 2018; Muis et al., 2006). However, further research is needed to better understand the phenomenon and to identify the factors that explain differences in epistemological beliefs in relation to each discipline (Rosman et al., 2020).

In this study, we examined the epistemological beliefs of first-year teacher trainees in two domains: science and history. The choice of these areas is justified, among others, by the availability of validated instruments in the literature. We did not use a general tool to conduct the survey. Instead, we relied on a questionnaire specifically designed to measure epistemological beliefs in science or history. Another aspect is the difference between the two domains. There are discrepancies in research paradigms and methodologies between the natural sciences and humanities. According to Biglan's (1973) classification of disciplines, natural sciences are considered hard sciences, while history is categorised as a soft discipline. While learning in hard disciplines usually relies on well-structured, clearly defined concepts, soft disciplines tend to be characterised by the presence of ill-defined forms of knowledge (Muis et al., 2006; Rosman et al., 2020; Schommer-Aikins et al., 2003). It is also crucial that all student teachers have a number of years of experience in both fields from their primary and secondary education. In Hungary, history is taught in Grades 5–12 and is a compulsory subject for the school-leaving examination. Science subjects are studied up to Grade 10. Those planning a career in science continue their studies in Grades 11 to 12 and then take a school-leaving examination in one or more science subjects. As the sample included not only future science and history teachers, we were also able to investigate the impact of university studies on domain-specific epistemological beliefs.

Although the teaching of the history of science plays an important role in science education (for details see Matthews, 2014) and can support the development of students' epistemological beliefs (e.g. Chen et al., 2022; Forato et al., 2012; Park et al., 2023), this research has not focused on the history of science but primarily on the epistemological beliefs of teacher candidates about history and science as two domains.

In addition to a variable-centred approach, we used a person-centred approach, k-means cluster analysis, to identify EB profiles in both science and history. As well as examining the characteristics of domain-specific EB profiles, we studied their relationships to gather information on the degree to which epistemological beliefs are domain-specific. The results allow a better understanding of the development of a multidimensional system of epistemological beliefs in science and history and provide a basis for recommendations for teacher education.

2 Development of Epistemological Beliefs

Like individual conceptions about knowledge and its limits and construction (Hofer & Bendixen, 2012; Schommer-Aikins, 2004), epistemological beliefs are regarded as a manifestation of epistemological cognition (Maggioni et al., 2009; Greene et al., 2016), which can act together in a complex system of personal epistemology (Schommer, 1990). These beliefs are socially and individually constructed (Merk et al., 2018; Muis et al., 2006).

Two basic theoretical approaches can be identified in the literature to describe the development of epistemological beliefs: the developmental and the multidimensional view. The developmental perspective considers epistemological beliefs along a continuum which consists of several hierarchical, qualitatively different stages, stances or positions (e.g. King & Kitchener, 2002; Kuhn & Weinstock, 2002). The multidimensional approach assumes several dimensions of epistemological beliefs (e.g. justification and development), and this dimensionality allows researchers to simultaneously analyse particular aspects of these beliefs (e.g. Hofer & Pintrich, 1997; Schommer, 1990; Schommer-Aikins, 2004).

In addition to developmental and multidimensional approaches, there are research directions with an integrative perspective (e.g. Bendixen & Rule, 2004; Peter et al., 2016), highlighting that the dimensions of epistemological beliefs evolve independently over time. One such approach is the TIDE (Theory of Integrated Domains in Epistemology) model, which accepts that such beliefs are both domain-general and domain-specific, and provides one of the most detailed descriptions of the contextual factors involved in shaping them (Muis et al., 2006). This model comprises four dimensions similar to those proposed by Hofer and Pintrich (1997). Two dimensions (certainty and simplicity) are tied to beliefs about knowledge, and two further dimensions (justification and source) are linked to beliefs about knowing. In the TIDE model, epistemological beliefs are in a hierarchical relationship, in which they mutually influence each other. In terms of the context in which beliefs are constructed, an improved version of the TIDE model classifies them as general, academic, domain-specific and topic-specific (Merk et al., 2018). General epistemological beliefs are formed in a non-academic context (e.g. the home environment), while academic epistemological beliefs are shaped through formal education. Domain-specific beliefs are shaped when individuals are exposed to particular fields, "domains", of study, for example, in higher education. Topic-specific epistemic beliefs are formulated around particular topics or theories. Within this multifaceted and wide-ranging system, domain-general and domain-specific beliefs and contexts are dynamically interrelated over time. At the beginning, general beliefs have a greater influence on academic beliefs, but, over time, academic beliefs reflect more strongly on domain-specific ones.

Confirming interactions empirically and exploring domain-general and domain-specific aspects of development are current research areas. In this regard, two main approaches can be identified in studies on epistemological beliefs (see Limón, 2006; Merk et al., 2018; Muis et al., 2006). One is between-person research, which compares different groups of people according to their epistemological beliefs (e.g. Guo et al., 2021; Stoel et al., 2017). The other direction is the within-person kind, which focuses on different types of such beliefs in the same individuals. Recent work has used a combination of the two methods (e.g. Merk et al., 2018; Rosman et al., 2020).

These studies have indicated domain specificity but have also shown that students from different domains espouse similar levels of beliefs and may hold similar views within certain dimensions (Muis et al., 2016). The results on the effect of gender are controversial. Several studies have found gender differences in epistemological beliefs (e.g. Chai et al., 2006; Hofer, 2000; Ozkal et al., 2010; Yang et al., 2016), while others have not (e.g. Chan et al., 2013; Conley et al., 2004; Lonka et al., 2021).

2.1 Science-Specific Epistemological Beliefs

Developing scientific thinking is a central aim of science education. The changing nature of science, a critical view of new scientific findings and an understanding of empirical evidence for science require well-developed epistemological beliefs about science and scientific knowledge (Halonen et al., 2003; Kampa et al., 2016; Lederman et al., 2015).

Two basic approaches have also been used in studies on epistemological beliefs in science. The first is the one-dimensional developmental model conceptualized by Kuhn (1991), based on earlier research by Perry (1970). This model describes different stages that people experience during their schooling, ranging from naïve beliefs to more sophisticated ones (Chen, 2012). Kuhn and Weinstock (2002) divided this developmental continuum into four stages: realist, absolutist, multiplist and evaluativist (Schiefer et al., 2022). The other principal line of research on epistemological beliefs argues for a multidimensional structure and a domain specificity of epistemological beliefs in the natural sciences (Kampa et al., 2016). This contemporary view is referred to as an independently operating model, which is based on an approach to epistemological conceptions (system of beliefs) that may have more or less independent dimensions for the nature of knowledge and knowing (Chen, 2012; Hofer, 2000). Furthermore, each dimension of an individual's scientific knowledge can develop independently along naïve and sophisticated scales (Bromme, 2005; Hofer, 2016).

In this study, we use the latter approach that epistemological beliefs have multiple dimensions and domain specificity, and we refer to a four-factor structure by Conley et al. (2004). Conley et al. (2004) proposed four dimensions of students' epistemological beliefs in science, further refining Hofer's (2000) and Elder's (2002) earlier research. According to this model, the domain of science includes beliefs about the source (beliefs about the knowledge that resides in external authorities), certainty (beliefs in the right answers), development (beliefs about scientific knowledge changing) and justification (beliefs about the role of experiments and how individuals justify knowledge) of knowledge and knowing (Conley et al., 2004; Schiefer et al., 2021). The four-dimensional structure has been successfully applied to various age groups, from elementary school children in Grades 3–4 to pre-service science teachers (e.g. Bahcivan, 2014; Chen, 2012; Conley et al., 2004; Özbay & Köksal, 2021).

2.2 History-Specific Epistemological Beliefs

Research on history-specific epistemological beliefs came to the fore after the turn of the millennium. Based on the literature in educational psychology and the relevant disciplines, Maggioni and her colleagues (e.g. Maggioni et al., 2004, 2009) developed a framework containing three epistemic stances, which describe development and changes in epistemic cognition in history teaching and learning. In a nutshell, the initial, copier stance is taken by people that do not differentiate between the past and history. The following, borrower stance is a transition between naïve and nuanced thinking and is characterised by subjectivity, with people choosing from various interpretations based on their judgement. The highest level of epistemic cognition is the criterialist stance, which includes knowledge of the interpretative nature of history and the use of discipline-specific research methods and instruments, such as an investigation of the author's perspective and intentions. The Beliefs about History Questionnaire (BHQ) was developed and validated using this theoretical framework (Maggioni et al., 2009) and is widely recognised by researchers, with adapted and reconsidered items having been published several times (e.g. Mierwald et al., 2017; Miguel-Revilla et al., 2021; Stoel et al., 2017).

Among recent investigations, the integrative approach by Stoel and his colleagues (2017) is particularly relevant because they combined developmental (King & Kitchener, 2002; Kuhn & Weinstock, 2002; Maggioni et al., 2009) and multidimensional (Hofer & Pintrich, 1997; Schommer, 1990) research directions. Considering the multidimensionality of the theoretical framework, the nature of historical knowledge and historical knowing can be fundamentally distinguished. The developmental direction ranges from naïve to subjective to nuanced thinking. Integrating these two approaches, a naïve view is that historical knowledge is simple and unmodifiable, and that it is derived from external objectivations, such as history textbooks. A subjectivist might think that the source of historical knowledge is the person and is therefore subjective. On the highest level, the constructivist idea is that historical knowledge is constructed and therefore uncertain, but many discipline-specific methods ensure a confirmation of reliability (Stoel et al., 2017). Based on this framework, Stoel et al. (2017) developed a questionnaire with five scales, three of which have been empirically validated. Although the instrument is being developed continuously, this theoretical foundation allows a multifaceted and history-specific but not topic-dependent analysis and characterisation of epistemological beliefs.

3 Examining Personal Epistemology: A Person-Centred Approach

The multidimensional approach provides an option to investigate how individuals' epistemological beliefs evolve (Kampa et al., 2016). Individual differences and developmental stages can be better detected in a person-centred approach and provide a more refined and differentiated picture of individuals' personal epistemology than the previous, variable-centred approach, which focused on means of EB dimensions across the whole sample (Schiefer et al., 2022). Person-centred analyses focus on clusters, or profiles, of observations, and their change over time or differences across factors. The most common person-centred statistical method is cluster analysis (CA, for example, k-means clustering) and latent profile analysis (LPA) (Gartstein et al., 2017). This approach can result in linear and non-overlapping profiles (persons who show a stronger or weaker affirmation of all epistemological belief dimensions), and it can also reveal nonlinear and overlapping profiles (persons who have stronger beliefs in some epistemological beliefs and weaker beliefs in others) (Schiefer et al., 2022). Person-centred analysis of students' or teacher candidates' epistemological beliefs is becoming increasingly common in science education research (for details see Chen, 2012; Dai & Cromley, 2014; Ferguson et al., 2020; Kampa et al., 2016; Schiefer et al., 2021), while it is even less frequent in history education research (Stoel, et al., 2022).

4 The Present Study

The aim of this study is to explore student teachers' epistemological beliefs at the beginning of their university studies in two fields, science and history. We used both variable-centred and person-centred methods to examine the developmental levels of dimensions of epistemological beliefs in both domains. The research questions are as follows:

RQ1: Is there a difference between pre-service teachers in science, history and other subjects in their developmental level of epistemological beliefs about science and history?
RQ2: Are there gender differences in the developmental levels of epistemological beliefs in the two domains?
RQ3: What EB profiles can be identified in the case of science and history?
RQ4: What is the relationship between the profiles for epistemological beliefs in the two domains?

Based on previous research, we formulated the following hypotheses:

H1a: Pre-service science teachers' epistemological beliefs about science are more sophisticated than those of others.
H1b: Pre-service history teachers' epistemological beliefs about history are more sophisticated than those of others.
H2: There are no significant gender differences among pre-service teachers in their epistemological beliefs.
H3: Person-centred analysis also identifies different EB profiles among university students than those of secondary school students.
H4: There is a link between the domain-specific profiles for science and history.

5 Methods

5.1 Participants

A total of 146 student teachers (61% female) participated in the study, all in the second semester of their first year. The sample represents 85% of the total first-year cohort at the university. Teacher trainees have two subjects. 22 participants in the sample study science (biology/chemistry/physics/earth science), 43 are students of history, and 81 study other subjects (e.g. Hungarian literature and grammar, foreign language, mathematics, art, music, physical education, information technology). The gender proportion is almost the same for the science and history students, but different for those in the other subjects (50%, 46.5% and 71.6% are females, respectively).

5.2 Procedure and Instruments

5.2.1 Procedure

All data were collected through online questionnaires via the eDia system (Csapó & Molnár, 2019). The questionnaires were completed in an introductory pedagogy course. Participation was voluntary and anonymous.

5.2.2 Measuring Epistemological Beliefs About Science

The student teachers' epistemic beliefs were measured with Conley et al.'s (2004) 26-item questionnaire to assess the following dimensions of epistemological beliefs: source (five items), certainty (six items), development (six items) and justification (nine items). The items were rated on a five-point scale (1 = strongly disagree; 5 = strongly agree). Since the items for the source and certainty dimensions reflect naïve beliefs, these were reversed during the data analysis so that higher scores would indicate more sophisticated beliefs. The Hungarian version of this instrument was used, which had been found to be reliable and valid for the 11th grade (Orosz & Korom, 2020).

Confirmatory factor analysis (CFA) was employed to examine the four-dimensional factor structure in this sample. It was necessary to omit two items (Nos. 21 and 23) from the justification scale based on the analysis. Subsequently, the 24 items showed a good fit to the expected four-factor model ($\chi^2(276) = 1121.80$, $p < 0.01$; CFI = 0.91, RMSEA = 0.05). The dimensions have acceptable internal consistency reliability (see Table 1).

5.2.3 Measuring Epistemological Beliefs About History

The Hungarian version (Kósa, 2020) of the questionnaire developed by Stoel et al. (2017) was used to examine epistemological beliefs about history. It contains a total of 26 statements to be evaluated on a six-point scale (1 = completely disagree; 6 = completely agree). The items are abstract, closed-ended statements, which are independent of any historical topics. The questionnaire was developed based on the multidimensional approach, which means that the statements can be categorized based on their content (historical knowing or historical knowledge) and their developmental stage (nuanced, subjective and naïve).

Table 1 Internal consistency (Cronbach's alpha and McDonald's omega), means, standard deviations and zero-order correlations for EB scales in science ($n = 146$)

EB scale	No. items	α	*ω*	*M*	*SD*	1	2	3
1 Source	5	0.76	0.76	3.39	0.72			
2 Certainty	6	0.75	0.77	3.80	0.60	0.56**		
3 Development	6	0.75	0.75	4.28	0.46	0.02	0.25**	
4 Justification	7	0.64	0.67	4.22	0.40	0.01	0.15	0.59**

**$p < 0.01$

Confirmatory factor analysis was used to detect the functioning of the questionnaire on the sample. Based on these results ($\chi^2(87)=121.13$, $p<0.01$; CFI = 0.89; RMSEA = 0.05), the three scales (historical knowing: nuanced; historical knowing: naïve; and historical knowledge: objective), which were validated by Stoel et al. (2017), were verified and were thus included in the final analysis. As regards internal consistency (Table 2), all three scales are moderately reliable.

5.3 Data Analysis

Mplus (version 8.4) was employed for confirmatory factor analysis, SPSS (version 27) for descriptive statistical analysis and cluster analysis, and Jamovi (version 2.3.26) for reporting McDonald's omega (ω) coefficient. GraphPad Prism (GraphPad Software version 8.0.1) was used for visual representation.

6 Results

6.1 Student Teachers' Epistemological Beliefs About Science

The student teachers hold quite sophisticated beliefs on the development ($M=4.28$, $SD=0.46$) and justification scales ($M=4.22$, $SD=0.40$) (see Table 1). The high average score in the development dimension assumes that students recognise that science is an evolving field and that scientific knowledge can change over time. Those with sophisticated beliefs about the justification of knowledge are more likely to use evidence, and they also believe more in the importance of scientific experiments in acquiring new knowledge (Conley et al., 2004). Lower mean scores were found for the source ($M=3.39$, $SD=0.72$) and certainty ($M=3.80$, $SD=0.60$) scales. This suggests that some student teachers believe that scientific knowledge originates from external authorities and that scientists know almost everything about science.

Before we examine the correlations between the epistemological beliefs about science dimensions, it is worth remembering that two of the scales on Conley's questionnaire consist of naïve statements (source and certainty), while two of the other scales contain sophisticated ones (development and justification). The source scale is highly correlated with the certainty scale (Pearson's $r=0.56$, $p<0.01$), and development is strongly correlated with the justification scale ($r=0.59$, $p<0.01$). No correlations or only weak ones can be detected between scales with oppositely expressed statements. These phenomena

Table 2 Internal consistency (Cronbach's alpha and McDonald's omega), means, standard deviations and zero-order correlations for EB scales in history ($n=146$)

EB scale	No. items	α	*ω*	*M*	*SD*	1	2
1 Knowing: nuanced (criteria)/ historical methodology	6	0.67	0.69	4.85	0.61		
2 Knowing: naïve (objective)	4	0.60	0.62	3.58	0.85	-0.07	
3 Knowledge: naïve (objective)	5	0.70	0.70	2.83	0.80	-0.21**	0.31**

**$p<0.01$

are consistent with the results of previous research (see Chen, 2012; Conley et al., 2004; Kampa et al., 2016).

6.2 Differences in Science by Gender and Subject

Examining gender differences in the epistemological beliefs about science within the subsamples, we only found significant differences among the pre-service science teachers. The t-test showed that the epistemological beliefs among males were more sophisticated than those among females in two dimensions, development ($M_{male}=4.47$, $SD=0.36$, $M_{female}=4.01$, $SD=0.32$, $t=2.595$, $p=0.017$) and justification ($M_{male}=4.43$, $SD=0.41$, $M_{female}=4.10$, $SD=0.30$, $t=2.105$, $p=0.048$).

A one-way analysis of variance was used to answer the third research question. After we compared the three subsamples (student teachers in science, history and other subjects), a significant difference was only found between the pre-service science teachers and other future teachers on the source scale, $F(2, 143)=3.47$, $p=0.034$. The post-hoc Dunn's test with Bonferroni revealed significant pairwise differences between the two subsamples, with an average difference in mean of 0.30 ($p=0.038$) in favour of future science teachers.

6.3 Student Teachers' Epistemological Beliefs About History

The student teachers in the study attained an average score of 4.85 ($SD=0.61$) on the historical methodology scale. The items for nuanced beliefs on this scale refer to the significance of the methodological criteria for historical analysis. The other two scales present unsophisticated assertions about the nature of knowledge and knowing. Therefore, a low average score on the scale indicates that the students reject a rigid viewpoint of historical facts and perceive historical events with a nuanced perspective. These future teachers achieved higher average scores on the knowing: naïve scale ($M=3.58$, $SD=0.85$) than on the knowledge: naïve one ($M=2.83$, $SD=0.80$), indicating that they agree less that contradictory or incomplete sources hinder historical research (Stoel et al., 2017).

We conducted a series of Pearson's correlations (Table 2) to ascertain the characteristics of the epistemological scales in history and to determine the relationship between them. With regard to the three history-specific epistemological scales, there is a weak negative correlation between the historical methodology and historical knowledge: objective scales ($r=-0.21$, $p<0.01$). This relationship shows that student teachers who tend to accept that historical knowledge is constructed on the basis of methodological criteria reject the notion that historical knowledge is fixed and monolithic. Between the two naïve scales (historical knowing: naïve and historical knowledge: objective), there is a moderate positive correlation ($r=0.31$, $p<0.01$). Student teachers who reject the simplicity of historical knowledge also disagree with the view that contradictory sources prevent them from reflecting on and interpreting past events.

6.4 Differences in History by Gender and Subject

We found no significant differences in epistemological beliefs about history between males and females in any of the subsamples. Analysing the effect of the subject studied with one-way ANOVA, we found differences in the historical methodology and historical knowing: naïve scales. Student teachers in history had a significantly more positive opinion of nuanced beliefs about history ($F(2, 143)=9.89$, $p<0.001$) than their peers in science (the average difference in the mean is 0.41 ($p=0.018$), as determined by the post-hoc Dunn's test) and other teachers (the average difference in the mean is 0.47 ($p<0.001$ based on the Dunn's test). Furthermore, a significant difference was found between student teachers in history and those in other subjects on the knowledge: naïve scale ($F(2, 143)=3.16$, $p=0.045$), with a difference in mean of 0.39 ($p=0.046$), as determined by the post-hoc Dunn's test. It can be concluded that the degree of dealing with history affects the development of epistemological beliefs for the advanced dimension.

6.5 Identification of EB Profiles

6.5.1 EB Profiles in Science

We used cluster analysis to explore individuals' personal epistemological profiles in science. Before the procedure, the student teachers' personality scores were standardised within the total sample and used for the cluster analyses. As a first step, we carried out a hierarchical cluster analysis with Ward's (1963) method based on squared Euclidean distances. The plotted dendrogram indicated three distinct clusters in our sample based on distances (see Appendix 1, Figures 3 and 4). In the second step, a non-hierarchical k-means cluster analysis was employed with three cluster solutions using simple Euclidean distance (Scholte et al., 2005; Vansteenkiste et al., 2009). We conducted a multivariate analysis of variance (MANOVA) to confirm that the three profiles differed significantly in students' epistemological beliefs in science. The results indicated a statistically significant overall difference between clusters, $F(8, 280)=51.31$, Wilks' $\Lambda=0.16$, $p<0.001$, partial $\eta^2=0.59$. Follow-up analyses of variance showed statistically significant univariate effects for all the dependent measures: F_S (2, 143) = 81.9, $p<0.001$, partial $\eta^2=0.58$; F_C (2, 143) = 56.6, $p<0.001$, partial $\eta^2=0.44$; F_D (2, 143) = 81.4, $p<0.001$, partial $\eta^2=0.53$; F_J (2, 143) = 39.7, $p<0.001$, partial $\eta^2=0.36$. Since the variances for each of these variables were not significantly different, a Tukey-B test was used in the post hoc analysis. The source dimension was statistically significantly different for all three clusters. Students in Cluster 2 and Cluster 3 scored statistically significantly higher on the development and justification scales than students in Cluster 1. In addition, student teachers in Clusters 1 and Cluster 2 had statistically significantly lower scores on the certainty dimension. Table 3 presents the mean scores for the three students' profiles in science and the existence of a significant difference between each variable in the clusters formed. The discriminant function analysis showed that overall group membership was accurately predicted for 83.6% of

Table 3 Descriptive statistics for EB clusters in science

EB scale	Cluster 1 $n=45$ (30.8%)		Cluster 2 $n=41$ (28.1%)		Cluster 3 $n=60$ (41.1%)	
	M	SD	M	SD	M	SD
Source	3.20^b	0.50	2.74^c	0.51	3.98^a	0.48
Certainty	3.50^b	0.45	3.44^b	0.55	4.28^a	0.37
Development	3.78^b	0.33	4.58^a	0.30	4.44^a	0.32
Justification	3.87^b	0.37	4.42^a	0.31	4.34^a	0.29

Superscript letters that differ in the same row indicate statistically significant differences in means at $p<0.05$

the cases. Prediction accuracy for Cluster 1 was 95.6%, for Cluster 2 it was 95.1%, and for Cluster 3 98.3%.

The three clusters (Fig. 1) we have identified were classified according to the description provided by Kampa et al. (2016). We used the system developed by Kampa et al. (2016) to name the groups and describe their characteristics. In naming the groups, we also highlighted the beliefs that are more sophisticated in the profile. Cluster 1 includes 45 (31%) student teachers whom we have labelled *slightly sophisticated.* This group is somewhat below the average for the whole sample ($M_S = 3.20$, $SD = 0.50$; $M_C = 3.50$, $SD = 0.45$; $M_D = 3.78$, $SD = 0.33$; $M_J = 3.87$, $SD = 0.37$). The distinctions between scales appear in the Cluster 2 with 41 (28%) members. In this cluster, students' mean scores for the source and certainty scales are lower than the mean scores for the whole sample ($M_S = 2.74$, $SD = 0.50$; $M_C = 3.44$, $SD = 0.54$), while their mean scores for the development and justification scales are higher than the mean for the whole sample ($M_D = 4.58$, $SD = 0.30$; $M_J = 4.42$, $SD = 0.31$). Kampa et al. (2016) called the group with this pattern *evidence-based/dynamic*, illustrating the coexisting naïve and advanced views of students. The *sophisticated* group (Cluster 3) includes 60 (41%) students who hold advanced beliefs with the highest average values ($M_S = 3.98$, $SD = 0.48$; $M_C = 4.28$, $SD = 0.37$; $M_D = 4.44$, $SD = 0.32$; $M_J = 4.34$, $SD = 0.28$) in all four dimensions. This pattern is the desired level of development of epistemological beliefs. Unlike Kampa et al. (2016), our analysis did not find a fourth, multiplist profile (quite sophisticated beliefs in the source and certainty dimensions and below-average beliefs in the justification and development dimensions). In Kampa's study, only 4.4% of 10th-grade students belonged to this group.

No significant differences were observed in the proportion of males and females in the three science profiles ($\chi^2(2) = 0.84$, $p = 0.66$), nor were significant differences found in the distribution of subjects studied across the profiles ($\chi^2(4) = 5.47$, $p = 0.24$).

Knowing the specific epistemological beliefs of students entering higher education in relation to their own subject can provide important information on the design of teacher education. Therefore, we examined how the 22 science-oriented student teachers are distributed across the three profiles. There are ten (45%) future teachers in the *sophisticated* group with the desired level of development and nine (41%) in the *slightly sophisticated* group. In addition, three teacher education students (14%) fall within the *evidence-based/dynamic* group. This result is similar to that of Kampa et al. (2016), where the majority of 10th-grade students were in the slightly sophisticated (41.8%) and sophisticated (41.9%) groups.

6.5.2 EB Profiles in History

In a way similar to the epistemological beliefs in science, cluster analysis was used to distinguish three groups in the sample (see Appendix 2, Figures 5 and 6) and label them naïve, transitional and nuanced (see Table 4, Fig. 2). The MANOVA was significant, confirming that there were statistically significant overall differences between the clusters: F(6, 282) = 61.65, Wilks' $\Lambda = 0.19$, $p < 0.001$, partial $\eta 2 = 0.56$. Follow-up ANOVAs showed statistically significant univariate effects for the 3 dependent variables, F_M (2, 143) = 38.0, $p < 0.001$, partial $\eta^2 = 0.35$; F_N (2, 143) = 90.9, $p < 0.001$, partial $\eta^2 = 0.56$; F_O (2, 143) = 45.7, $p < 0.001$, partial $\eta^2 = 0.39$. Tukey-B test showed that students in Cluster 1 had statistically significantly lower scores on the nuanced knowledge measure than students in the two other clusters. For the two dimensions with naïve beliefs on knowing and knowledge, there was a statistically significant difference for all

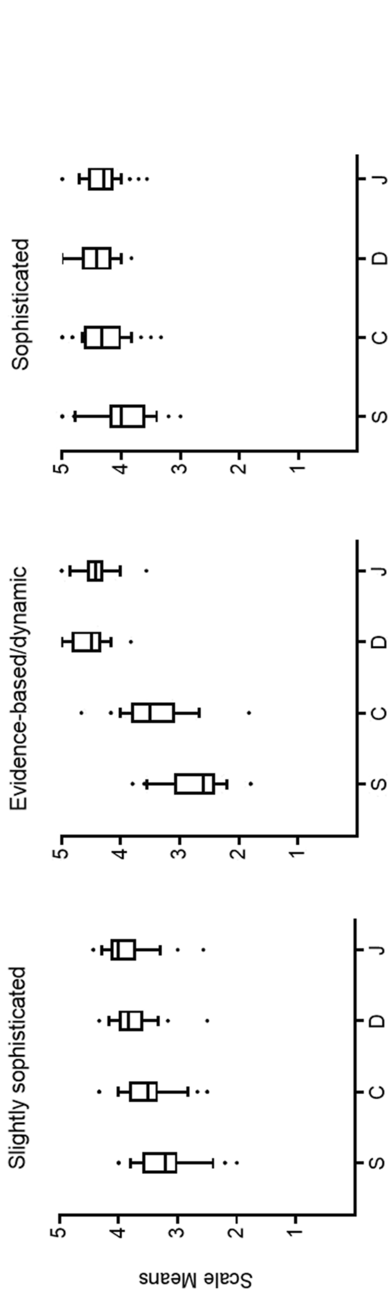

Fig. 1 Means and distributions for each EB dimension of science within the three groups. S = source; C = certainty ; D = development; J = justification

Table 4 Descriptive statistics for EB clusters in history

EB scale	Cluster 1 $n=55$ (37.7%)		Cluster 2 $n=33$ (22.6%)		Cluster 3 $n=58$ (39.7%)	
	M	SD	M	SD	M	SD
Knowing: nuanced (criteria)/ historical methodology	4.39[b]	0.51	5.12[a]	0.51	5.13[a]	0.46
Knowing: naïve (objective)	3.73[b]	0.59	4.54[a]	0.59	2.90[c]	0.53
Knowledge: naïve (objective)	3.43[a]	0.57	2.76[b]	0.73	2.30[c]	0.61

Superscript letters that differ in the same row indicate statistically significant differences in means at $p<0.05$

clusters. The discriminant function analysis showed that overall group membership was accurately predicted for 80.9% of the cases. The prediction accuracy for Cluster 1 was 100%, for Cluster 2 it was 100%, and for Cluster 3 98.3%.

The characteristics of each group can be determined by comparing them with those of other groups based on the average values for each epistemological scale. The group of *naïve* thinkers (Cluster 1) ($M_M=4.39$, $SD=0.51$; $M_N=3.73$, $SD=0.60$; $M_O=3.41$, $SD=0.58$) accepted statements that knowledge is fixed and comes from a certain source, while they were less likely to agree with nuanced statements about knowing. On the other hand, in the case of the *nuanced* thinkers (Cluster 3) ($M_M=5.13$, $SD=0.46$; $M_N=2.89$, $SD=0.54$; $M_O=2.30$, $SD=0.62$), they evaluated nuanced statements decidedly more positively and, at the same time, rejected naïve ones consistently. The third group (Cluster 2) forms a kind of transition ($M_M=5.12$, $SD=0.51$; $M_N=4.54$, $SD=0.59$; $M_O=2.76$, $SD=0.73$) whom we have labelled *transitional*. In their case, acceptance of nuanced beliefs can be observed, but, at the same time, statements on the historical knowing: naïve scale were also typically rated positively.

This finding is similar to that of Stoel et al. (2017) that the change from being naïve to a nuanced thinker can result in specific epistemological patterns. The students they called procedural objectivists (Kuhn, 2000, cited in Stoel et al., 2017) typically evaluated all three scales positively. This means that students tend to accept methodological criteria to evaluate historical knowledge, but they do this in order to acquire specific, fixed, certain knowledge about the past. In our investigation, it can be observed that the student teachers agreed both with naïve and nuanced beliefs about historical knowing but that their beliefs about historical knowledge were also developed because they gave a lower rating to statements on the historical knowledge: objective scale. We believe that this pattern indicates that the future teachers in the transitional group were already aware of the subjective and constructed nature of historical knowledge, as well as the methodological background of its creation. However, at the same time, in the case of the latter, their beliefs had not yet solidified, and they did not consistently reject naïve views. Thus, they accepted a specific authority figure as the source of knowledge, for example.

There is no significant difference in the proportion of males and females in the EB profiles in history ($\chi^2(2)=1.38$, $p=0.501$). However, there is a significant difference in the distribution of subjects studied across the profiles ($\chi^2(4)=15.92$, $p=0.003$), with the pre-service history teachers being overrepresented in the nuanced group. The distribution of the 43 future history teachers in the three profiles was as follows: 27 students (62%) in the nuanced group, eight (19%) in the transitional group and eight (19%) in the naïve group.

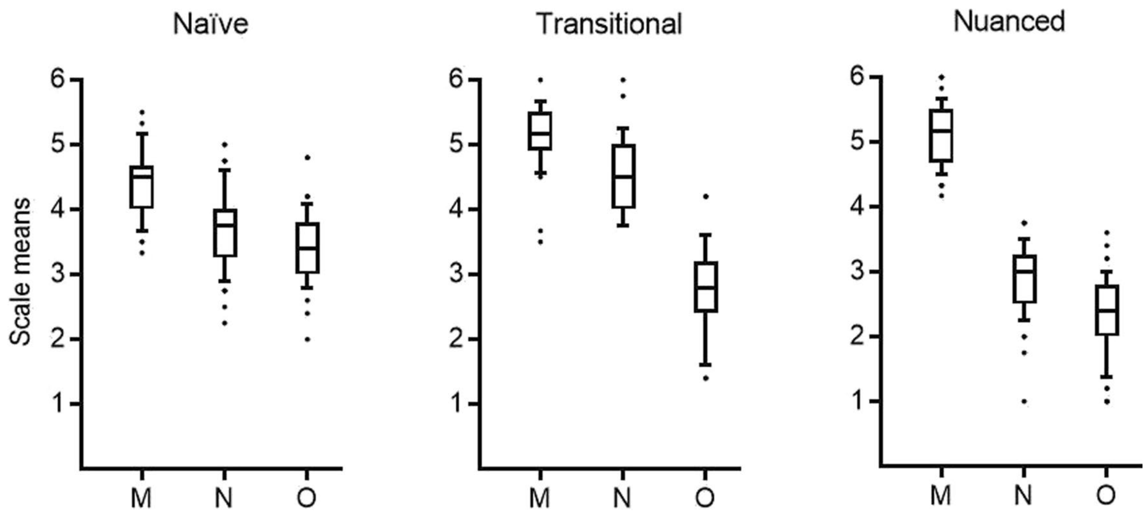

Fig. 2 Means and distributions for each EB dimension of history within the three groups. M = historical methodology; N = historical knowing: naïve; O = historical knowledge: objective

6.6 Relationship Between the Epistemological Belief Profiles in the Two Domains

After an analysis of the relationship between history- and science-specific epistemological scales, the results show several significant correlations (Table 5). The historical methodology scale has a weak positive correlation with the certainty scale in science (Pearson's $r=0.19$, $p<0.05$). Student teachers who use methodological criteria to interpret the past in the case of history are more likely to agree that there are not always right answers in science. There are also moderate positive correlations between the historical methodology and the development ($r=0.44$, $p<0.01$) and justification ($r=0.52$, $p<0.01$) scales. Accepting the existence of methodological tools and processes to determine the reliability of sources about the past in history is related to agreement on the changing nature of scientific knowledge and the importance of conducting scientific experiments in the natural sciences. The historical knowledge: objective scale has significant negative correlations with almost all the science-specific epistemological scales. This points to a relationship between domain-specific beliefs.

With the cross-tabulation analysis, it is possible to observe similar patterns in the two epistemological areas and compare the epistemological profiles developed in each scientific field and thus examine the discipline specificity of the epistemological beliefs (Table 6). The chi-square test was significant ($\chi^2(4)=37.00$, $p<0.001$). The two variables are therefore interdependent, and the correlation (Kendall's tau-b = 0.40, $p<0.001$) was strong between the epistemological development of the two areas. Based on the results, it can be concluded that students ($n=30$) who hold rather naïve beliefs about history (54.5%) also typically had slightly sophisticated opinions about the nature of scientific knowledge and knowing in science (66.7%). At the same time, in the case of the nuanced thinkers about history ($n=37$, 63.8%), a sophisticated approach to science was also observed (61.7%).

7 Discussion

This study examined the epistemological beliefs of first-year teacher trainees in relation to science and history. The sample contained a cohort of teacher education students in their first year divided into three subsamples according to subject (science, history and other).

For the first two research questions, we used a variable-centred approach and a between-subjects design (comparing epistemic beliefs about science and history among student teachers in different disciplines), while, in the case of the third and fourth research

Table 5 Zero-order correlations for EB scales in science and history ($n=146$)

EB scale	S1	S2	S3	S4	H1	H2
S1 Source						
S2 Certainty	0.56**					
S3 Development	0.02	0.25**				
S4 Justification	0.01	0.15	0.59**			
H1 Historical methodology	0.05	0.19*	0.44**	0.52**		
H2 Historical knowing: naïve	-0.14	-0.20*	-0.03	0.11	-0.07	
H3 Historical knowledge: objective	-0.40**	-0.41**	-0.26**	-0.17*	-0.21**	0.31**

*$p<0.05$, **$p<0.01$; S: science; H: history

Table 6 Cross-tabulation of clusters of EBs in science and history ($n = 146$)

Clusters of EBs in science		Clusters of EBs in history			Total *n* Percent-age
		Naïve	Transitional	Nuanced	
Slightly sophisticated	*n*	30	4	11	45
	Percentage (% within S/H)	20.5 (66.7/54.5)	2.8 (8.9/12.1)	7.5 (24.4/19)	30.8
Evidence-based/ Dynamic	*n*	16	15	10	41
	Percentage (% within S/H)	11 (39/29.1)	10.3 (36.6/45.5)	6.8 (24.4/17.2)	28.1
Sophisticated	*n*	9	14	37	60
	Percentage (% within S/H)	6.2 (15/16.4)	9.6 (23.3/42.4)	25.3 (61.7/63.8)	41.1
	Total *n*	55	33	58	146
	Percentage	37.7	22.6	39.7	100

S: science; H: history

questions, we employed a person-centred approach to identify EB profiles and analyse their characteristics. Then we compared the domain-specific EB profiles using cross-tabulation and made within-person comparisons (the epistemological beliefs of the same individuals in different domains).

Our results show that the questionnaires also represent a reliable measurement at the higher education level. Previously, these instruments were mainly used among primary or secondary school students (e.g. Conley et al., 2004; Kampa et al., 2016, Stoel et al., 2017). Most of the first-year teacher trainees we studied had sophisticated beliefs about science and the emergence of scientific knowledge on the development and justification scales. This demonstrates that they think of science as an evolving and changing field and believe that scientific experimentation is important in acquiring and validating new knowledge. Consistent with previous studies (Chen, 2012; Conley et al., 2004), our study reported lower EB scores on the certainty and source scales. These results show that a proportion of student teachers also believe in the certainty of knowledge and that scientific knowledge comes from external authority.

Similar trends were found for history. The student teachers scored relatively high on the scale for nuanced beliefs in assessing historical methodology and lower on the scales for naïve beliefs (knowing: naïve and knowledge: naïve). This indicates that the majority of the future teachers hold nuanced views about historical knowledge and its discipline-specific methods and agree less that contradictory or incomplete sources are an obstacle to historical research.

Several studies have shown that the development of epistemological beliefs is related to an individual's academic performance (e.g. Chen & Pajares, 2010; Schommer, 1993; Schommer-Aikins & Easter, 2006). Therefore, we assumed that in the case of epistemological beliefs in science (hard disciplines), the pre-service science teachers would have higher average scores than future teachers of history or other subjects, while the future history teachers would have more sophisticated epistemological beliefs about history than student teachers in other disciplines. For science, our data did not confirm our hypothesis, as there was only one scale, the source dimension, where there was a significant difference between pre-service science teachers and other student teachers. This phenomenon is related to the extended TIDE framework's assumption that domain-specific beliefs can evolve outside of the academic context (Merk et al., 2018). As concerns epistemological beliefs about history (a soft discipline), the influence of the discipline was pronounced. Student teachers in history had more sophisticated beliefs about the methods of historical epistemology than students of science or other disciplines. They also performed significantly better on the historical knowing: naïve scale. This somewhat nuances the research findings of Rosman and his colleagues (Rosman et al., 2020) regarding the epistemic perceptions of learners in hard and soft disciplines, and aligns with the particularities of discipline-specific socialization (Tabak et al., 2010).

The results on the effect of gender are controversial in the literature. In our study, we found no significant gender effect in the three subsamples by subject in terms of epistemological beliefs about science or history. In only one case was a significant difference found: males agreed more with the statements on the development and justification dimensions of the science EB. However, it is important to note that despite this difference, the means were high for both males and females. Our results are consistent with research by Conley et al. (2004), who found that gender does not play such a large role in epistemological thinking. It is likely that other characteristics of learners, teachers and practical, inquiry-oriented teaching are more influential in the formation of beliefs.

The person-centred analysis provided a more accurate picture of the dimensions of epistemological beliefs. Three EB profiles representing different developmental levels were identified in both science and history. We named them in line with the literature: slightly sophisticated, evidence-based/dynamic and sophisticated in science (Kampa et al., 2016) and naïve, transitional and nuanced in history (Stoel et al., 2017). In the case of science, we did not identify the multiplist profile (quite sophisticated beliefs in the source and certainty dimensions and below-average beliefs in the justification and development dimensions), which also included only a small number of secondary school students in Kampa et al.'s (2016) study. This result can be explained by the fact that a rather naïve perception of the justification and development dimensions is less common among university students. However, further research is needed to confirm this assumption.

Previous research has mainly identified EB profiles in science among younger age groups, secondary and primary school students (e.g. Chen, 2012; Kampa et al., 2016; Schiefer et al., 2021, 2022). Schiefer et al. (2021) have shown that differences in EBs about science already emerge among primary school children (3rd and 4th graders). They also identified three EB profiles in science (relatively absolutist/statist, absolutist/evidence-based and sophisticated). In a study integrating six surveys, Schiefer et al. (2022) showed that primary and upper secondary school students exhibit specific EB profiles in science that vary through their education and are influenced by a number of student characteristics. Our results show that the evolution of domain-specific EBs is a long process and that the differences between individuals persist even among undergraduates.

The results of our study provide useful information on the assessment of the domain generality and specificity of epistemological beliefs. The analysis of the correlation of the epistemological scales about science and history reflects moderate domain generality, confirmed by the cross-tabulation analysis with the EB profiles in science and history. This means that student teachers who interpret the generation of historical knowledge as a creative process typically do not accept the absolute and fixed nature of natural science knowledge. It can be observed that those whose thinking is nuanced about history also have fundamentally nuanced beliefs about science, similarly to naïve thinkers, who believe that knowledge in both fields is given and can be fully known.

In sum, the findings confirm our hypotheses with one exception. In contrast to history, the impact of academic studies is not significant in science. The first-year history teacher trainees hold more sophisticated beliefs about history than the future teachers in other courses of study. In contrast, the science students do not have more advanced beliefs about science than their peers studying other subjects. The fact that no differences were found between the three subsamples by discipline in the science EB dimensions and only two dimensions in history suggests that domain-general influences might also play a role in the shaping of discipline-specific epistemological beliefs. Using k-means cluster analysis, the person-centred approach points to the existence of different EB profiles among the university students and shows that there are significant individual differences in both science and history. However, a comparison of the domain-specific profiles also demonstrates that the epistemological beliefs are similar in evolutionary terms. The student teachers who espouse more sophisticated beliefs in one domain are also likely to hold more sophisticated beliefs in the other. In our study, a quarter of the future teachers hold the most advanced, sophisticated EBs in both domains.

7.1 Conclusions

Our research confirms the approach that individuals' domain-specific epistemological beliefs develop in relation to domain-general beliefs (Buehl & Alexander, 2006; Hofer, 2016; Muis et al., 2006). In a combined (dimensional and developmental) approach, the exploration and comparison of domain-specific profiles through person-centred analysis open up new directions in the study of epistemological beliefs about history and science (e.g. Schiefer et al., 2022; Stoel et al., 2022). The results, in addition to contributing to a better understanding of the development of epistemological beliefs, also carry important implications for teacher education.

An important aim of education is to help students shape their epistemological beliefs. This can be achieved if teachers themselves have sophisticated beliefs and are able to consciously support the development of students' epistemological beliefs in their subjects, even at the primary school level. To achieve this, particular attention should be paid to the training of future teachers. Our results show that around half of first-year teacher trainees in science (45%) have sophisticated beliefs about scientific knowledge and how it is generated. The proportion is higher (62%) for pre-service history teachers with regard to their beliefs about history. Therefore, in both disciplinary and teaching methodology courses, it is necessary to diagnose, monitor, and develop the domain-specific epistemological beliefs of student teachers and introduce them to teaching practices that help improve students' epistemological beliefs. For example, how they can use the history and nature of science to shape their students' epistemological beliefs (e.g. Chen et al., 2022; Forato et al., 2012).

Although our research did not investigate student teachers' epistemological beliefs about pedagogy and psychology, based on previous research (Ferguson & Bråten, 2018; Lonka et al., 2021) it can be assumed that there may be significant differences between students in these domains as well. Since we found a relationship between the level of development of different domain-specific beliefs, we hypothesise that student teachers who espouse sophisticated views about both science and history (a quarter of the students in our sample) also tend to hold more sophisticated views about pedagogical knowledge and its origins. However, this may be nuanced by the effect of context. For many topics, student teachers may have knowledge from non-academic sources (Kızkapan et al., 2023; Merk et al., 2018).

The epistemological beliefs of student teachers not only influence the processing of educational literature, but also affect the formation of their conceptions about teaching, the role of the teacher and the learning process (Cheng et al., 2009; Eryasar & Kilinc, 2022). Therefore, special attention should be paid during teacher training to provide student teachers with the opportunity to study educational and psychological literature, discuss scientific findings, acquire knowledge of research methodology, and design and implement their own projects and empirical studies (e.g. Abd-El-Khalick, 2001; Akerson et al., 2006; Deniz, 2011; Guilfoyle et al., 2020).

7.2 Limitations and Further Studies

As a limitation of the research, it is important to clarify that our sample is relatively small, and, although it is a good representation of a university's first-year cohort in teacher training, it only allowed limited analyses. The small number of students and the reason that they belong to one university affect the representativeness of the sample and the generalisability of the conclusions.

Furthermore, it is also important to note that the two instruments applied two different scales (the questionnaire on epistemological beliefs about science used a 5-point Likert scale, while the questionnaire on epistemological beliefs about history used a 6-point scale with no neutral points). The latter questionnaire forces the participant to choose anyway. The absence of a neutral answer may therefore cause some "noise". The relatively low internal consistency of the questionnaires, especially in the case of the history questionnaire, may be due to the uncertainty arising from the characteristics of the scale, in addition to the small sample size. As preliminary studies have also reported lower reliability for some dimensions of the questionnaire on beliefs about history, it is important to further investigate and improve this instrument in the future.

For the person-centred analysis of epistemological beliefs, k-means clustering was chosen due to the sample size. In a further study involving a larger sample, the use of latent profile analysis may also be beneficial.

Clustering provides information about a group of individuals with similar patterns based on the variables included, which is an extra piece of information for interpreting the data in relation to the whole population. The majority of average scores for the resulting clusters were above the neutral point of the measure for each dimension of science (except for source), so the majority of teacher candidates in each cluster agreed with the statements. Therefore, the measure is less able to differentiate for naïve views. Despite this, pattern differences were detected. This study has shown that, although the epistemological beliefs of first-year student teachers are generally advanced, differences can be detected which may have an impact on their preparation for teaching. However, further research (both quantitative and qualitative) is needed to confirm these findings.

Since we studied first-year teacher trainees, it is worth following the changes in their domain-specific beliefs during the teacher training. Further research could also be carried out on a larger sample in several domains (including other disciplines, such as education, in addition to science and history) to compare domain-specific profiles and their relationships.

Appendix 1

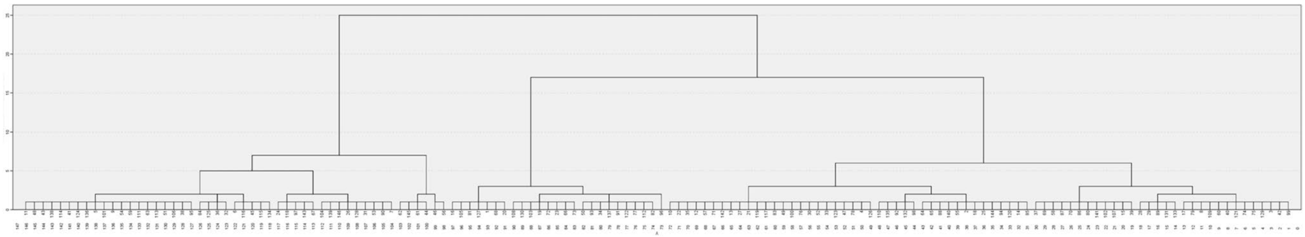

Fig. 3 Dendrogram of hierarchical cluster analysis for EB in science

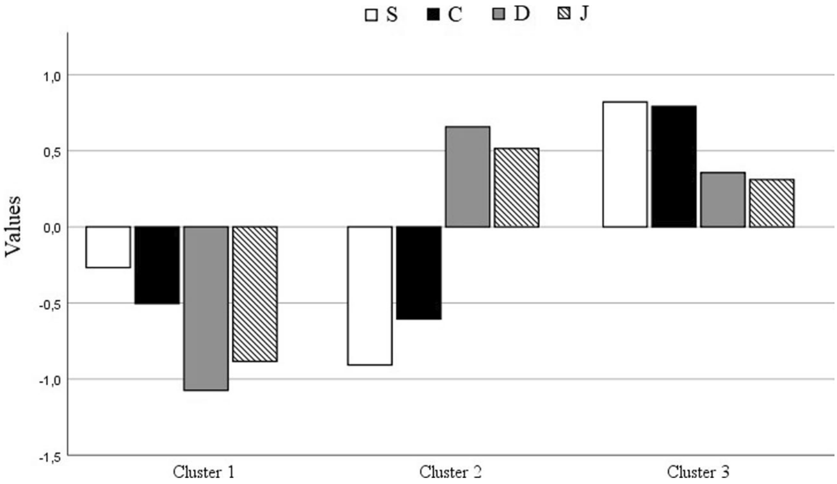

Fig. 4 Bar graph of k-means clustering for EB in science (S = source; C = certainty ; D = development; J = justification)

Appendix 2

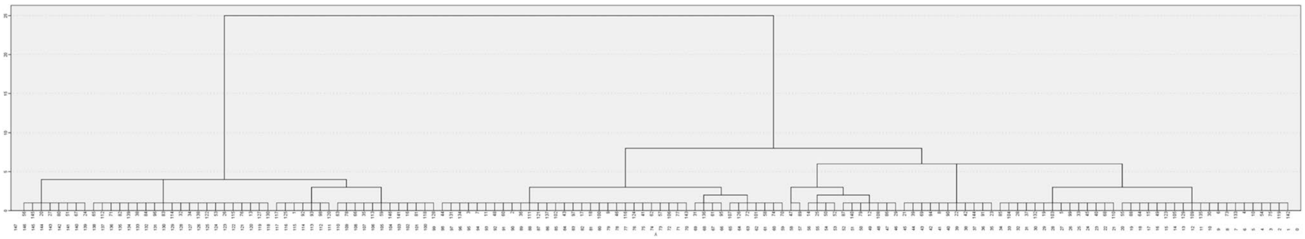

Fig. 5 Dendrogram of hierarchical cluster analysis for EB in history

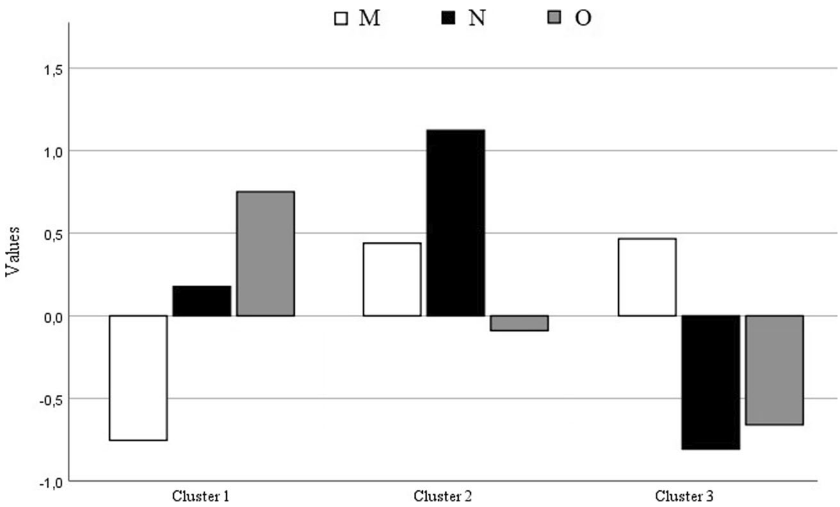

Fig. 6 Bar graph of k-means clustering for EB in history (M = historical methodology; N = historical knowing: naïve; O = historical knowledge: objective)

Acknowledgements We thank the student teachers who participated in the study.

Author Contributions **Erzsébet Korom**: Conceptualization; Methodology; Formal analysis; Project administration; Supervision; Writing—original draft; Writing—review & editing; Funding acquisition.

Márió Tibor Nagy: Conceptualization; Methodology; Data curation; Formal analysis; Writing—original draft; Writing—review & editing.

Maja Majkić: Conceptualization; Methodology; Formal analysis; Writing—original draft; Writing—review & editing.

Funding This study was funded by the Research Programme for Public Education Development of the Hungarian Academy of Sciences (KOZOKT2021-16). The publication was funded by the University of Szeged Open Access Fund (Grant No. 6563).

Data Availability Data will be made available on request.

Declarations

Conflict of Interest The authors declare that there are no financial or personal competing interests that could have appeared to influence the work reported in this paper.

References

Abd-El-Khalick, F. (2001). Embedding nature of science instruction in preservice elementary science courses: Abandoning scientism, but…. *Journal of Science Teacher Education, 12*(3), 215–233. https://doi.org/10.1023/a:1016720417219

Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: Preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching, 43*(2), 194–213. https://doi.org/10.1002/tea.20099

Bahcivan, E. (2014). Examining relationships among Turkish pre-service science teachers' conceptions of teaching and learning, scientific epistemological beliefs and science teaching efficacy beliefs. *Journal of Baltic Science Education, 13*(6), 870–882. https://doi.org/10.33225/jbse/14.13.870

Bendixen, L. D., & Rule, D. C. (2004). An integrative approach to personal epistemology: A guiding model. *Educational Psychologist, 39*(1), 69–80. https://doi.org/10.1207/s15326985ep3901_7

Biglan, A. (1973). Relationships between subject matter characteristics and the structure and output of university departments. *Journal of Applied Psychology, 57*(3), 204–213. https://doi.org/10.1037/h0034699

Bromme, R. (2005). Thinking and knowing about knowledge: A plea for and critical remarks on psychological research programs on epistemological beliefs. In M. H. G. Hoffmann, J. Lenhard, & F. Seeger (Eds.), *Activity and sign – Grounding mathematics education* (pp. 191–201). Springer. https://doi.org/10.1007/0-387-24270-8_17

Buehl, M. M., & Alexander, P. A. (2005). Motivation and performance differences in students' domain-specific epistemological belief profiles. *American Educational Research Journal, 42*(4), 697–726. https://doi.org/10.3102/00028312042004697

Buehl, M. M., & Alexander, P. A. (2006). Examining the dual nature of epistemological beliefs. *International Journal of Educational Research, 45*(1–2), 28–42. https://doi.org/10.1016/j.ijer.2006.08.007

Çam, A. (2015). Primary pre-service teachers' epistemological beliefs and their teaching and learning experiences. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(2), 381–390. https://doi.org/10.12973/eurasia.2015.1351a

Chai, C. S., Khine, M. S., & Teo, T. (2006). Epistemological beliefs on teaching and learning: A survey among pre-service teachers in Singapore. *Educational Media International, 43*(4), 285–298. https://doi.org/10.1080/09523980600926242

Chan, R.Y.-Y., Huang, J., Hui, D., Li, S., & Yu, P. (2013). Gender differences in collaborative learning over online social networks: Epistemological beliefs and behaviors. *Knowledge Management & E-Learning: An International Journal, 5*(3), 234–250. https://doi.org/10.34105/j.kmel.2013.05.017

Chen, J. A. (2012). Implicit theories, epistemic beliefs, and science motivation: A person-centered approach. *Learning and Individual Differences, 22*(6), 724–735. https://doi.org/10.1016/j.lindif.2012.07.013

Chen, J. A., & Pajares, F. (2010). Implicit theories of ability of Grade 6 science students: Relation to epistemological beliefs and academic motivation and achievement in science. *Contemporary Educational Psychology, 35*(1), 75–87. https://doi.org/10.1016/j.cedpsych.2009.10.003

Chen, S. Y., Chen, C. H., & Liu, S. Y. (2022). History of science reading materials as everyday homework to improve middle school students' epistemological beliefs about science. *International Journal of Science and Mathematics Education, 20*(Suppl 1), 69–92. https://doi.org/10.1007/s10763-022-10285-3

Cheng, M. M. H., Chan, K.-W., Tang, S. Y. F., & Cheng, A. Y. N. (2009). Pre-service teacher education students' epistemological beliefs and their conceptions of teaching. *Teaching and Teacher Education, 25*(2), 319–327. https://doi.org/10.1016/j.tate.2008.09.018

Conley, A. M. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology, 29*(2), 186–204. https://doi.org/10.1016/j.cedpsych.2004.01.004

Csapó, B., & Molnár, G. (2019). Online diagnostic assessment in support of personalized teaching and learning: The eDia system. *Frontiers in Psychology, 10*, 1522. https://doi.org/10.3389/fpsyg.2019.01522

Dai, T., & Cromley, J. G. (2014). The match matters: Examining student epistemic preferences in relation to epistemic beliefs about chemistry. *Contemporary Educational Psychology, 39*(3), 262–274. https://doi.org/10.1016/j.cedpsych.2014.06.002

Deniz, H. (2011). Examination of changes in prospective elementary teachers' epistemological beliefs in science and exploration of factors mediating that change. *Journal of Science Education and Technology, 20*(6), 750–760. https://doi.org/10.1007/s10956-010-9268-x

Elder, A. D. (2002). Characterizing fifth grade students' epistemological beliefs in science. In P. R. Pintrich (Ed.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 347–364). Lawrence Erlbaum Associates Publishers.

Eryasar, A. S., & Kilinc, A. (2022). The Coherence Between Epistemologies and SSI Teaching. *Science & Education, 31*, 123–147. https://doi.org/10.1007/s11191-021-00200-7

Ferguson, L., & Bråten, I. (2018). Student teachers' beliefs about learning, teaching, and teaching knowledge: A qualitative study. *Teacher Education and Practice, 31*(3), 348–365.

Ferguson, S. L., Moore, E. W. G., & Hull, D. M. (2020). Finding latent groups in observed data: A primer on latent profile analysis in Mplus for applied researchers. *International Journal of Behavioral Development, 44*(5), 458–468. https://doi.org/10.1177/0165025419881721

Fives, H., & Buehl, M. M. (2008). What do teachers believe? Developing a framework for examining beliefs about teachers' knowledge and ability. *Contemporary Educational Psychology, 33*(2), 134–176. https://doi.org/10.1016/j.cedpsych.2008.01.001

Forato, T. C. M., de Andrade Martins, R., & Pietrocola, M. (2012). History and Nature of Science in High School: Building Up Parameters to Guide Educational Materials and Strategies. *Science & Education, 21*, 657–682. https://doi.org/10.1007/s11191-011-9419-3

Gartstein, M. A., Prokasky, A., Bell, M. A., Calkins, S., Bridgett, D. J., Braungart-Rieker, J., Leerkes, E., Cheatham, C. L., Eiden, R. D., Mize, K. D., Jones, N. A., Mireault, G., & Seamon, E. (2017). Latent profile and cluster analysis of infant temperament: Comparisons across person-centered approaches. *Developmental Psychology, 53*(10), 1811–1825. https://doi.org/10.1037/dev0000382

Green, H. J., & Hood, M. (2013). Significance of epistemological beliefs for teaching and learning psychology: A review. *Psychology Learning & Teaching, 12*(2), 168–178. https://doi.org/10.2304/plat.2013.12.2.168

Greene, J. A., Sandoval, W. A., & Bråten, I. (2016). Future directions for epistemic cognition research. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 495–510). Routledge.

Greene, J. A., Cartiff, B. M., & Duke, R. F. (2018). A meta-analytic review of the relationship between epistemic cognition and academic achievement. *Journal of Educational Psychology, 110*(8), 1084–1111. https://doi.org/10.1037/edu0000263

Guilfoyle, L., McCormack, O., & Erduran, S. (2020). The "tipping point" for educational research: The role of pre-service science teachers' epistemic beliefs in evaluating the professional utility of educational research. *Teaching and Teacher Education, 90*, 103033. https://doi.org/10.1016/j.tate.2020.103033

Guo, J., Hu, X., Marsh, H. W., & Pekrun, R. (2021). Relations of epistemic beliefs with motivation, achievement, and aspirations in science: Generalizability across 72 societies. *Journal of Educational Psychology, 114*(4), 734–751. https://doi.org/10.1037/edu0000660

Halonen, J. S., Bosack, T., Clay, S., McCarthy, M., Dunn, D. S., Hill, G. W., McEntarffer, R., Mehrotra, C., Nesmith, R., Weaver, K. A., & Whitlock, K. (2003). A Rubric for Learning, Teaching, and Assessing Scientific Inquiry in Psychology. *Teaching of Psychology, 30*(3), 196–208. https://doi.org/10.1207/S15328023TOP3003_01

Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25*(4), 378–405. https://doi.org/10.1006/ceps.1999.1026

Hofer, B. K. (2016). Epistemic cognition as a psychological construct. In J. A. Greene, W. A. Sandoval, & I. Bråten (Eds.), *Handbook of epistemic cognition* (pp. 19–38). Routledge. https://doi.org/10.4324/9781315795225

Hofer, B. K., & Bendixen, L. D. (2012). Personal epistemology: Theory, research, and future directions. In K. R. Harris, S. Graham, T. Urdan, C. B. McCormick, G. M. Sinatra, & J. Sweller (Eds.), *APA educational psychology handbook, Vol. 1: Theories, constructs, and critical issues* (pp. 227–256). American Psychological Association.

Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*(1), 88–140. https://doi.org/10.3102/00346543067001088

Kampa, N., Neumann, I., Heitmann, P., & Kremer, K. (2016). Epistemological beliefs in science – a person-centered approach to investigate high school students' profiles. *Contemporary Educational Psychology, 46*, 81–93. https://doi.org/10.1016/j.cedpsych.2016.04.007

King, P. M., & Kitchener, K. S. (2002). The reflective judgment model: Twenty years of research on epistemic cognition. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 37–61). Lawrence Erlbaum Associates Publishers.

Kızkapan, O., Nacaroğlu, O., & Kırmızıgül, A. S. (2023). Pre-service science teachers' epistemic beliefs, nature of science views, and beliefs in pseudoscience. *Science & Education*. https://doi.org/10.1007/s11191-023-00450-7

Kósa, M. (2020). Egy történelemről alkotott episztemológiai nézetek vizsgáló kérdőív magyarországi adaptálása [Hungarian version of a questionnaire on epistemological beliefs about history]. *Iskolakultúra, 30*(4), 97–109. https://www.iskolakultura.hu/index.php/iskolakultura/article/view/33398
Kuhn, D. (1991). *The skills of argument*. Cambridge University Press.
Kuhn, D., & Weinstock, M. (2002). What is epistemological thinking and why does it matter? In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 121–144). Lawrence Erlbaum Associates Publishers.
Kutluca, A. Y., & Mercan, N. (2022). Exploring the effects of preschool teachers' epistemological beliefs on content-based pedagogical conceptualizations and PCK integrations towards science teaching. *European Journal of Science and Mathematics Education, 10*(2), 170–192. https://doi.org/10.30935/scimath/11661
Lederman, N. G., Schwartz, R., & Abd-El-Khalick, F. (2015). Nature of science, assessing of. In R. Gunstone (Ed.), *Encyclopedia of science education* (pp. 694–698). Springer. https://doi.org/10.1007/978-94-007-2150-0_12
Limón, M. (2006). The domain generality-specificity of epistemological beliefs: A theoretical problem, a methodological problem or both? *International Journal of Educational Research, 45*(1–2), 7–27. https://doi.org/10.1016/j.ijer.2006.08.002
Lonka, K., Ketonen, E., & Vermunt, J. D. (2021). University students' epistemic profiles, conceptions of learning, and academic performance. *Higher Education, 81*(4), 775–793. https://doi.org/10.1007/s10734-020-00575-6
Maggioni, L., Alexander, P. A., & VanSledright, B. A. (2004). At the crossroads: The development of epistemological beliefs and historical thinking. *European Journal of School Psychology, 2*(1–2), 169–197.
Maggioni, L., VanSledright, B. A., & Alexander, P. A. (2009). Walking on the borders: A measure of epistemic cognition in history. *The Journal of Experimental Education, 77*(3), 187–214. https://doi.org/10.3200/jexe.77.3.187-214
Matthews, M. R. (Ed.). (2014). *International handbook of research in history, philosophy and science teaching*. Springer.
Merk, S., Rosman, T., Muis, K. R., Kelava, A., & Bohl, T. (2018). Topic specific epistemic beliefs: Extending the theory of integrated domains in personal epistemology. *Learning and Instruction, 56*, 84–97. https://doi.org/10.1016/j.learninstruc.2018.04.008
Mierwald, M., Seiffert, J., Lehmann, T., & Brauch, N. (2017). Fragebogen auf dem Prufstand. Ein Beitrag zur Erforschung und Weiterentwicklung eines bestehenden Instruments zur Erfassung epistemologischer Überzeugungen in der Domäne Geschichte. In M. Waldis & B. Ziegler (Eds.), *Forschungswerkstatt Geschichtsdidaktik 15: Beiträge zur Tagung "Geschichtdidaktik empirisch 15"* (pp. 177–190). Hep-Verlag.
Miguel-Revilla, D., Carril-Merino, T., & Sánchez-Agustí, M. (2021). An examination of epistemic beliefs about history in initial teacher training: A comparative analysis between primary and secondary education prospective teachers. *The Journal of Experimental Education, 89*(1), 54–73. https://doi.org/10.1080/00220973.2020.1718059
Muis, K. R., Bendixen, L. D., & Haerle, F. C. (2006). Domain-generality and domain-specificity in personal epistemology research: Philosophical and empirical reflections in the development of a theoretical framework. *Educational Psychology Review, 18*(1), 3–54. https://doi.org/10.1007/s10648-006-9003-6
Muis, K. R., Trevors, G., Duffy, M., Ranellucci, J., & Foy, M. J. (2016). Testing the TIDE: Examing the nature of students' epistemic beliefs using a multiple methods approach. *The Journal of Experimental Education, 84*(2), 264–288. https://doi.org/10.1080/00220973.2015.1048843
Özbay, H. E., & Köksal, M. S. (2021). Middle School Students' Scientific Epistemological Beliefs, Achievements in Science and Intellectual Risk-Taking. *Science & Education, 30*, 1233–1252. https://doi.org/10.1007/s11191-021-00217-y
Orosz, Z. G., & Korom, E. (2020). A tudásról és a tudomány működéséről alkotott nézetek vizsgálata 11. évfolyamos diákok körében [Exploring 11th-grade students' beliefs on knowledge and how science works]. XX. Országos Neveléstudományi Konferencia, Debreceni Egyetem [XX. National Conference on Educational Science, University of Debrecen, Hungary]. http://onk.hu/2020/downloads/ONK_2020_Absztraktkotet_vegleges.pdf#page=377
Ozkal, K., Tekkaya, C., Sungur, S., Cakiroglu, J., & Cakiroglu, E. (2010). Elementary students' scientific epistemological beliefs in relation to socio-economic status and gender. *Journal of Science Teacher Education, 21*, 873–885. https://doi.org/10.1007/s10972-009-9169-0
Park, W., Erduran, S., Song, J., & Kim, M. (2023). "It's a lesson with no correct answer": Design issues in preservice teachers' use of history of science for lesson planning. *International Journal of Science Education, 45*(3), 181–203. https://doi.org/10.1080/09500693.2022.2154132

Peffer, M. E., & Ramezani, N. (2019). Assessing epistemological beliefs of experts and novices via practices in authentic science inquiry. *International Journal of STEM Education, 6*(3), 1–23. https://doi.org/10.1186/s40594-018-0157-9

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years*. Academic Press.

Peter, J., Rosman, T., Mayer, A.-K., Leichner, N., & Krampen, G. (2016). Assessing epistemic sophistication by considering domain-specific absolute and multiplicistic beliefs separately. *British Journal of Educational Psychology, 86*(2), 204–221. https://doi.org/10.1111/bjep.12098

Rosman, T., Seifried, E., & Merk, S. (2020). Combining Intra- and Interindividual Approaches in Epistemic Beliefs Research. *Frontiers in Psychology, 11*, 570. https://doi.org/10.3389/fpsyg.2020.00570

Saylan, A., Armağan, F. Ö., & Bektaş, O. (2016). The relationship between pre-service science teachers' epistemological beliefs and preferences for creating a constructivist learning environment. *European Journal of Science and Mathematics Education, 4*(2), 251–267. https://doi.org/10.30935/scimath/9468

Schiefer, J., Bernholt, A., & Kampa, N. (2021). A closer look at elementary school students' epistemic beliefs – Latent profiles capturing concepts of knowledge and knowing in science. *Learning and Individual Differences, 92*, 102059. https://doi.org/10.1016/j.lindif.2021.102059

Schiefer, J., Edelsbrunner, P. A., Bernholt, A., Kampa, N., & Nehring, A. (2022). Epistemic beliefs in science—A systematic integration of evidence from multiple studies. *Education Psychology Review, 34*(3), 1541–1575. https://doi.org/10.1007/s10648-022-09661-w

Scholte, R. H. J., van Lieshout, C. F. M., de Wit, C. A. M., & van Aken, M. A. G. (2005). Adolescent personality types and subtypes and their psychosocial adjustment. *Merrill-Palmer Quarterly, 51*(3), 258–286. https://doi.org/10.1353/mpq.2005.0019

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82*(3), 498–504. https://doi.org/10.1037/0022-0663.82.3.498

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology, 85*(3), 406–411. https://doi.org/10.1037/0022-0663.85.3.406

Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist, 39*(1), 19–29. https://doi.org/10.1207/s15326985ep3901_3

Schommer-Aikins, M., & Easter, M. (2006). Ways of knowing and epistemological beliefs: Combined effect on academic performance. *Educational Psychology, 26*(3), 411–423. https://doi.org/10.1080/01443410500341304

Schommer-Aikins, M., Duell, O. K., & Barker, S. (2003). Epistemological beliefs across domains using Biglan's classification of academic disciplines. *Research in Higher Education, 44*, 347–366. https://doi.org/10.1023/A:1023081800014

Stoel, G., Logtenberg, A., Wansink, B., Huijgen, T., Van Boxtel, C., & Van Drie, J. (2017). Measuring epistemological beliefs in history education: An exploration of naïve and nuanced beliefs. *International Journal of Educational Research, 83*, 120–134. https://doi.org/10.1016/j.ijer.2017.03.003

Stoel, G., Logtenberg, A., & Nitsche, M. (2022). Researching epistemic beliefs in history education: A review. *Historical Encounters, 9*(1), 11–34. https://doi.org/10.52289/hej9.102

Tabak, I., Weinstock, M. P., & Zviling-Beiser, H. (2010). Discipline-specific socialization: a comparative study. In K. Gomez, L. Lyons, & J. Radinsky (Eds.), *Learning in the Disciplines: Proceedings of the 9th International Conference of the Learning Sciences: Vol. 1, Full Papers* (pp. 842–848). International Society of the Learning Sciences.

Trautwein, U., & Lüdtke, O. (2007). Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology, 32*(3), 348–366. https://doi.org/10.1016/j.cedpsych.2005.11.003

Vansteenkiste, M., Sierens, E., Soenens, B., Luyckx, K., & Lens, W. (2009). Motivational profiles from a self-determination perspective: The quality of motivation matters. *Journal of Educational Psychology, 101*(3), 671–688. https://doi.org/10.1037/a0015083

Ward, J. H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association, 58*(301), 236–244. https://doi.org/10.1080/01621459.1963.10500845

Yang, F. Y., Huang, R., & Tsai, I. (2016). The effects of epistemic beliefs in science and gender difference on university students' science-text reading: An eye-tracking study. *International Journal of Science and Mathematics Education, 14*(3), 473–498. https://doi.org/10.1007/s10763-014-9578-1