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The Epistemic Beliefs of Fourth Graders about the Verification of Second-Hand Knowledge and Its Knowledge Sources

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Abstract

Only little is known about the epistemic beliefs of elementary school children. In this exploratory study, semi-structured interviews were used to solicit epistemic beliefs of fourth grade students (n = 98; mean age = 10 years, 4 months) about the verification of second-hand knowledge. The data analysis was based on the Qualitative Content Analysis (Mayring, 2001), supported with Atlas.ti software, and yielded a high in interrater reliability (Cohen, 1960; κ = 0.94). In fourth grade students, a complex system of beliefs was identified about strategies of second-hand knowledge verification (independent strategies n = 8; dependent strategies n = 3), knowledge sources (human sources n = 4; non-human n = 4), and different source selection criteria (n = 8). Moreover, some students (n = 10) mentioned a cognitive process that they would employ to identify the best possible sources for the processes of knowledge verification, similar to following a decision tree. The discussion explores meaning of the identified multi-faceted and partially meta-cognitive nature of belief systems for the conceptualization of the developmental, dimensional, and situational frameworks as they exist currently.

Keywords: Epistemic belief, personal epistemology, knowledge justification, Knowledge sources, higher-order thinking, children.

Highlights:

- An exploratory study with Fourth Grade Students (n = 98) using semi-structured interviews.
- Identified complex epistemic belief systems based on their diversity and interconnectedness.
- Students had epistemic beliefs about strategies of second-hand knowledge verification (n = 11), knowledge sources (n = 8), and different source selection criteria (n = 8).
- Some students expressed thinking process about source selection that can be conceptually located at a higher-order of thinking.
- The complexity of epistemic belief systems challenges the explanatory power of existing frameworks.

1. Introduction

Every day in this world, people – young and old alike – are exposed to new knowledge. They encounter knowledge in diverse situations and from various sources. This can occur, for instance, in more informal settings, when talking with friends or colleagues, watching TV, and surfing the web, while at other times knowledge might be more sought out in more formal learning environments, such as school, college, or an evening class at the art museum. A person can be confronted with two types of new knowledge. First-hand knowledge would be new to a person because it emerges from an act of generating new knowledge by the person her/himself, such as the outcome of conducting a series of experiments or making an extrapolation from a personal experience.

Second-hand knowledge, in contrast, is knowledge that is generated by somebody else, but is experiences by person as new when she/he is exposed to it by the means of a knowledge sources, like a book, the internet, and other people. No matter what knowledge people absorb and for what reasons, they might be challenged to verify the trustworthiness and relevance of the incoming information, before making an informed decision or coding it into long-term memory. From a cognitive perspective, the task to evaluate existing knowledge, or second-hand knowledge, requires individuals to have a set of strategies, categories, and sources to verify knowledge and to reflect, monitor, and regulate the verification processes at a higher level of their thinking. Beliefs about knowledge and knowing, such as ideas about the certainty of knowledge, awareness of different knowledge structures, and processes of scrutinizing its truth, become an important aspect of navigating knowledge successfully in everyday' s world. These beliefs have been defined as 'epistemic' beliefs because they are concerned about an individual's understanding of the nature of knowledge and processes of knowing (Hofer & Pintrich, 1997, 2002). This psychological construct is also referred to as personal epistemology.

At this point in time, few empirical studies exist that have explored the epistemic beliefs of elementary school children. Not even a handful of studies exist that shed light on children's epistemic beliefs about the verification processes of second-hand knowledge in particular. Due to the lack of research with younger populations, most of the explanatory power of existing frameworks in the field of personal epistemology is grounded in research conducted with adult populations (Authors, ####; Wildenger, Hofer, & Burr, 2010). In this light, the purpose of this study was to explore the epistemic beliefs of fourth grade students (n = 98) about the verification of second-hand knowledge with a particular focus on their understanding of strategies, criteria, and sources in the knowledge verification process. Because of the lacking research dedicated to this age group, I deliberately chose the design of an exploratory study using a set of semi-structured interview questions to permit an unbiased and open-minded solicitation and exploration of students espoused (not enacted) epistemic beliefs.

2. The Field of Personal Epistemology in Consideration of Elementary School Children

The field of personal epistemology is dedicated to researching the beliefs of individuals about the nature of knowledge and processes of knowing and their educational implications for learning and instruction (Authors, ####; Hofer & Pintrich, 2002; Khine, 2008; Brownlee, Schraw, & Berthelsen, 2011). William J. Perry (1970) originated the field with his seminal work on ethical and intellectual development of college-age students. Since then, the field has been enjoying increasing popularity among researchers in education sciences. Since the change of the century, several studies have been conducted with adolescent populations moving gradually towards younger ages (e.g., Schommer-Aikins, Duell, & Hutter, 2005; Trautwein & Lüdtke, 2007; Qian & Pan, 2002), while still only very few studies exist that have explored the potential outset of personal epistemology in the early years of children (e.g., Astington, Pelletier, & Homer, 2002; Burr & Hofer, 2002). Being approached from both sides, the epistemic beliefs in elementary school children is one of the least researched areas in the field of personal epistemology.

2.1 Frameworks

Understanding the development of the field reveals that most of the existing frameworks have been predominately validated by research conducted with participants in their adulthood and some in their adolescence and, consequently, limited in their explanatory powers to these age groups. Three types of frameworks can be identified that are qualitatively distinct in their conceptual focus of development, dimensions, and context. These frameworks are briefly reviewed next.

Developmental frameworks

Several developmental frameworks exist that theorize the construct of personal epistemology as a stage-like progression of epistemic understandings that are qualitatively distinct from each other (Baxter Magolda, 1992; King & Kitchener, 1994; D. Kuhn, 1991; Perry, 1970). For example, Perry (1970) proposed the aforementioned nine-stage scheme to conceptualize what he termed as 'ethical and intellectual development', while King and Kitchener (1994) identified a seven-stage framework to explain the development of 'reflective judgments'. A condensed version of these frameworks is D. Kuhn's (1999) developmental model of critical thinking which describes epistemic development in three distinct developmental levels of 'epistemic understanding': *Absolutism, Multiplism,* and *Evaluativism*.

Absolutism defines the developmental level of a person who views knowledge as more objective, simple, and dichotomous; *Multiplism* a person who perceives knowledge as increasingly subjective, complex, and relativistic, and *Evaluativism* a person who integrates both subjective and objective views of knowledge and considers its complexity and uncertainty in relation to its context (D. Kuhn, 1999; D. Kuhn, Cheney, & Weinstock, 2000; D. Kuhn & Weinstock, 2002).

Dimensional frameworks

Two frameworks – and derivations thereof, can be identified that explain personal epistemology as a system of beliefs that can be organized as a set of distinct, singular, but intertwined dimensions. Hofer and Pintrich's (Hofer, 2001; Hofer & Pintrich, 1997) framework conceptualizes personal epistemology as 'epistemic theories' which encompass four identifiable, interrelated dimensions that develop in reasonable, predictable directions. The first two dimensions theorize the *Nature of knowledge* in terms of: (1) the *Simplicity of knowledge* (i.e., the relative connectedness of knowledge) and (2) the *Certainty of knowledge* (i.e., the stability of knowledge and the strength of the supporting evidence). The third and fourth dimensions theorize *Processes of knowing* and pertain to: (3) the *Justification of knowledge* (i.e., the procedures to evaluate and warrant knowledge claims) and (4) the *Source of knowledge* (i.e., where knowledge resides; internally and/or externally). Schommer-Aikins' (2004; Schommer, 1990) earlier framework describes a system of 'epistemic beliefs', which encompasses two additional belief dimensions about the *Nature of learning* focusing on: (5) the *Speed of learning* (i.e., where learning either occurs gradually, quickly or not at all) and (6) the *Ability to learn* (i.e., where knowledge is innate and fixed or the ability to learn can be acquired).

Contextual framework

Hammer and Elby (2002) proposed a framework that defines personal epistemology as 'fine-grained cognitive resources' that are highly sensitive to and dependent on the context of an individual. The framework has a strong foothold in the field of science education. Research studies informed by this framework are most often conducted within the context of actual classroom settings (Louca, Elby, Hammer, & Kagey, 2004; Rosenberg, Hammer, & Phelan, 2006; Sandoval & C¸am, 2011). In this framework, fine-grained epistemic resources are categorized in four areas: (1) *Nature and sources of knowledge* (i.e., knowledge as propagated stuff, free creation, and fabricated stuff), (2) *Epistemological activities* (i.e., the accumulation, formation, and checking of knowledge), (3) *Epistemological forms* (i.e., stories, rules, facts, and games), and (4) *Epistemological stances* (i.e., acceptance, understanding, and puzzlement). The framework focuses on the importance of the situational context that activates the epistemic resources of a whole group of learners and backseats the agency of individual learners (Hammer & Elby, 2002; Rosenberg, et al., 2006).

2.2 Personal epistemology as a component of higher-order thinking processes

Over the years, different research studies explored the relationship between personal epistemology and higher-order thinking. Higher-order thinking encompasses the construct of meta-cognition, which was defined by Flavell (1979) as cognition that reflects on, monitors, or regulates other cognitive operations (Bromme, Pieschl, & Stahl, 2009; D. Kuhn, 2000; Schraw & Moshman, 1995). For example, advanced levels of epistemic beliefs were found to be correlated with more proficient levels of reasoning skills (Chandler, Boyes, & Ball, 1990), strategy use and monitoring (Bendixen & Hartley 2003; Schommer, Crouse & Rhodes, 1992), and text comprehension and processing (Kardash & Howell, 2000).

In their frameworks, Kitchener (1983), D. Kuhn (1999), and Hofer (2004) conceptualized personal epistemologies structurally similar to constructs of higher-order thinking (Bromme, et al., 2009). Kitchener (1983) developed a three-level model of cognitive processing to account for "complex monitoring involved when older adolescents and adults are faced with ill-structured problems" (King & Kitchner, 2002, p. 37). The three levels include: 1) *Cognition* (i.e., first-order cognitive processes used when engaged in computing, memorizing, and reading), *Meta-cognition* (i.e., second-order cognitive processes used to monitor and regulate cognitive processes at the first-order), and *Epistemic cognition* (i.e., third-order cognitive processes used to reflect and assess "the limits of knowing, the certainty of knowing, and criteria for knowing" (Kitchener, 1983, p. 222). D. Kuhn (1999, 2000) and Hofer (2004) also proposed that personal epistemology is an aspect of higher-order thinking. They embed personal epistemology as a component within meta-cognition.

At this second-level of higher-order thinking, D. Kuhn and Hofer conceptualize following three components: 1) *Meta-cognitive knowing* (i.e., knowledge about one owns declarative knowledge/ knowing what), 2) *Meta-strategic knowing* (i.e., knowledge about one owns procedural knowledge/ knowing how), and 3) *Epistemological meta-knowing* and *Epistemological metacognition*, respectively.

2.3 Personal epistemology research on elementary school children

Studies of different research designs have investigated the personal epistemology in elementary school children ranging from Kindergarten to sixth grade in age groups. Four types of studies could be identified, all of which were focused on domain-specific beliefs about the nature and processes of scientific knowledge. First, quantitative studies used questionnaires that were originally developed for adults (Duell & Schommer-Aikins, 2001; Schommer-Aikins, Duell, & Hutter, 2005) or created new questionnaires for children in particular (Conley, Pintrich, Vekiri & Harrison, 2004; Elder, 2002). These instruments assessed beliefs about the verification of knowledge as a single dimension. They did not permit a more open-ended approach to solicit more fine-grained epistemic beliefs about knowledge verification. Second, task-based studies used materials, such as different scientific or socio-scientific arguments that children were asked to evaluate (Ryu & Sandoval, 2011; Yang & Tsai, 2010). Using sorting activities allowed the researchers to identify different epistemic criteria. Because the tasks were purposefully designed to identify a predefined scope of epistemic criteria, the studies did not allow to openly exploring students' beliefs about the justification and source of knowledge. Third, studies that focused on the analysis of classroom discourse to identify epistemic beliefs in individual students and/or epistemic patterns across classrooms (Louca, et al., 2004; Rosenberg, et al., 2006). With their more open-ended design and the use of inductive coding schemes, these types of study designs would have had great potential to identify fine-grained epistemic beliefs; but, no study could be identified that focused on the exploration of the justification and sources of knowledge in elementary-school-aged children. Fourth, two interview studies were identified that used open-ended survey questions (Elder, 2002) and open-ended face-to-face interview questions (Kittleson, 2011), which permitted the solicitation of more fine-grained epistemic beliefs about the justification and source of knowledge. These two studies are reviewed next.

Elder (2002) conducted a questionnaire study that included three open-ended questions and a scale to assess students' epistemic beliefs about science in fifth-grade students (n = 211) recruited from nine classrooms in a large, urban school district in Southern California. Elder grouped students according to two dimensions: 1) weather they believed that the source of knowledge stemmed from an active or passive agent, and 2) weather they believed that the sources of knowledge stemmed from an independent or dependent endeavor. For the first dimension, students who were assigned to an *active role of agent* believed that knowledge originates from active ventures, such as thinking, interacting with things, exploring places, or studying materials, while students who were assigned to a *passive role of agent* expressed beliefs that ideas arise from a passive manner, such as one's mind/brain/head and from teachers, books, or family members. For the second dimension, students who were assigned to an *independent endeavor* believed that ideas come from independent ventures like one's mind/brain/head or thinking, wondering, and being curious, while students who were assigned to a *dependent venture* expressed beliefs that ideas come from teachers, books, or family members or from activities that involved the use of external sources. These results demonstrate that elementary school students hold more multi-faceted beliefs about the justification and source of knowledge and render the existing, single dimensions of knowledge justification (Hofer & Pintrich, 1997; Schommer-Aikins, 2004) a rather simplistic in their conceptualization.

Kittleson (2011) conducted face-to-face interviews with third-grade students (n = 19) over the course of two science lessons in a suburban elementary school in the mid-Atlantic region of the USA. The interviews focused on the four dimensions proposed in Hofer and Pintrich's (1997) framework. Kittleson found that beliefs about the justification and source of knowledge were based on weather knowledge is based on authoritative sources and/ or emerged from a person's activity. Student responses were assigned to different codes that defined following beliefs: 1) *Scientists use second-hand knowledge*, such as reading books and research on the computer, 2) *Scientists use first-hand sources of information*, such as learning from direct experience and conducting tests or experiments, 3) *Scientists use tools* like microscopes and magnifying glasses, and a combination code 4) *Scientists use a combination of first-hand sources and second-hand sources of information*. Kittleson used codes that resembled the conceptualizations of Hofer and Pintrich's (1997) framework.

In her analyses, Kittleson keep the dimensions of justification and source of knowledge jointly together and allowed codes to cut across both dimensions, while, she coded students' beliefs about the certainty dimension of knowledge separately. Her study demonstrated that beliefs about the justification and source of knowledge have more facets than dimensions and that both dimensions are closely interweaved with each other.

Based on the evidence provided in both studies, it can be claimed that epistemic beliefs of elementary school students about the justification of science knowledge were more diverse than expected. The diversity included, but was not limited to, following facets: 1) the justification of first-hand and second-hand knowledge, 2) source independent and dependent strategies of knowledge verification, and 3) passive and active strategies of knowledge verification. Both studies demonstrated that these facets were intertwined and assembled beliefs together beliefs about the justification and source of knowledge. For example, students believed that a scientist could verify second-hand knowledge dependent on external sources (e.g., scientific books) using an active strategy of knowledge verification (e.g., studying materials). It would be intriguing to know now, how such multi-faceted beliefs would change developmentally over time and contextually from situation to situation. Unfortunately, at this point in time, no research exists that has been conducted to explore this level of complexity in elementary school children's personal epistemology. This finding aligns with the general work of Greene and colleagues (Greene, et al., 2008; Murphy, et al., 2007) who have made the case that processes of knowledge justification are multi-faceted in their nature and should be theorized and measured accordingly.

3. Research Objective and Question

The study was part of large research project that focused on the nature of personal epistemologies of elementary students in general. The study's objective was to explore the espoused epistemic beliefs of fourth grade students about the processes they would use to justify and scrutinize existing knowledge. Specifically, the main research question was: *How do fourth grade students believe they can verify second-hand knowledge?* Sub questions were: *What strategies do they use to verify knowledge and why?* and *What sources do they use to verify knowledge and why?* A qualitative research approach was employed to permit a careful exploration of epistemic beliefs in children without expecting them to perform well in methodological approaches and match up with existing theories that have been used to assess and explain the personal epistemology of adult populations. The outcomes of the study were to reveal a more precise scientific understanding of fourth graders' personal epistemology that would provide insights on how to improve student learning, achievement, and epistemic development in classroom education.

4. Methods

4.1 Participants

Ninety-eight fourth grade school students in Germany participated in this study. Purposeful sampling was used to account for a diverse and balanced sample of diverse student characteristics (Cohen, Manion, &Morrison, 2000; Mertens, 1998). Ten students were sampled from each of the ten participating classrooms, accordingly. Tracking numbers (TN) were assigned to individual participants to indicate their student characteristics: Classroom, Student number, Gender, Age, and Achievement level (e.g., D7M 11,75 -) and to reference their quotations in the result section.

Sample

The sample (n = 98) included fifty male (TN: M) and forty-eight female (TN: F) students. Their age ranged from nine years and eight months to twelve years and four months with the mean age being ten years and four months (TN: Age). Ten students had a different cultural background other than German (Russian n = 5; Indian n = 2; Iraqi n = 1; Lebanese n = 1; and Turkish = 1). Eighteen students were identified by the school system as students with special educational needs (i.e., students with learning disabilities n = 12; students with intellectual disabilities n = 2; students who were gifted and talented n = 2; students with language difficulties n = 1; and students with physical disabilities n = 1). Furthermore, students were ranked by their classroom teachers on their overall academic achievement ranging from high achievers (n = 21; TN: + +), good achievers (n = 23; TN: +), average achievers (n = 23; TN: 0), low achievers (n = 20; TN: --), to poor achievers (n = 11; TN: --). The study was conducted in ten different classrooms (A, B, C, D, E, F, G, H, I, and K). All research sites were public elementary schools, had no specific religious affiliation, and were evenly distributed across different neighborhoods in a city in Northern Germany. The classroom size ranged from twenty-five to thirty co-educated students.

German elementary school system

In Germany, children enter the Grundschule at the age of six and remain together through fourth grade (KMK, 2013). Often students remain with the same classroom teacher across two or more grade levels.
Elementary school students attend a relatively short school day for 12 months out of the year with short breaks throughout (Ashwill, 1999; KMK, 2013). Information on the German elementary school system (KMK, 2013) and a cross-cultural comparison with the USA are reviewed elsewhere in more detail (Authors, ####).

4.2 Semi-structured interviews

Semi-structured interviews were conducted to solicit the epistemic beliefs about knowledge verification from students. This technique combines a highly-structured question set with the flexibility to ask ad hoc questions which emerge during the interview (Cohen, et al., 2000; Bogdan & Biklen, 1982). The question set encompassed following questions, "How can you check existing knowledge? How can you verify what you know? What knowledge sources do you use and why?", and ad hoc questions would be asked to encourage students to further elaborate their answers. All interviews were video-recorded. The first ten recordings were reviewed by a second researcher to provide peer feedback on the interviewer performance, such as, quality of interview data and potential interviewer biases. No adjustments were necessary.

4.3 Procedure

The duration of the data collection for one set of ten students recruited from one classroom was about one week, accumulating into an overall time frame of ten weeks. During the first two days of a week, the researcher participated in classroom activities to allow students to get to know the researcher and to build rapport. During the three remaining days of the week, each of the ten students was interviewed for about 15 to 25 minutes in an empty study room of the school building. The interviews were videotaped and transcribed.

4.4 Data analysis

Methodological background

The researcher used the method of *Qualitative Content Analysis* (Mayring, 2002), which evolved from the classical, more quantitative method of content analysis (Kohlbacher, 2005; Titscher, Meyer, Wodak, & Vetter, 2000). Within this method, a systematic, theory-guided approach is taken to text analysis using inductive coding schemes. This method combines two methodological principles: (a) theory-guided investigation, and (b) openness to context, themes, and individual variation (Glaeser & Laudel, 1999). The method includes three procedural steps of analysis (Kohlbacher, 2005; Mayring, 2002):

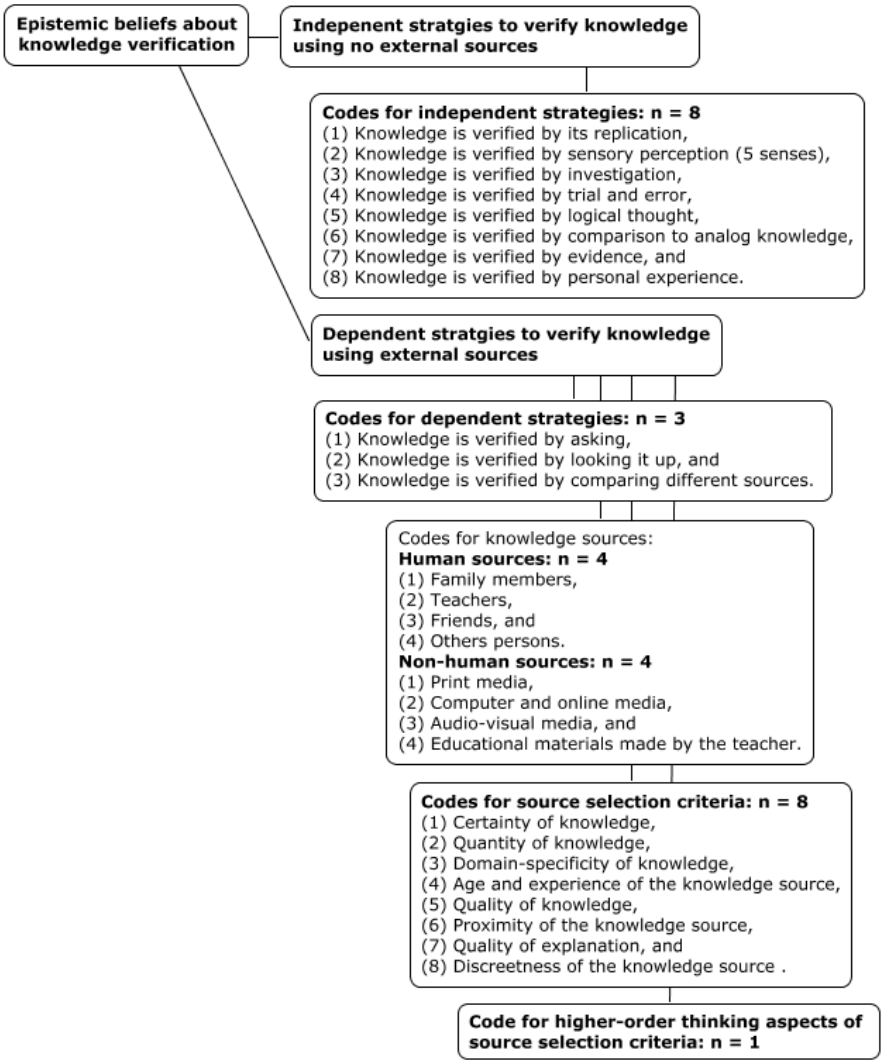
(1) The *summarizing* aims to reduce the data into a manageable body that represents the meaning of the original data. In this process, the data of each participant are summarized and generalized.
(2) The *explicating* attempts to describe, cleanse, and further condense the data into descriptive summaries. The datais divided into meaningful categories that are guided by the questions. The descriptive summaries aim to accurately represent the data context for individual participants and across all participants. Categories are developed and (re-) examined in an iterative process.
(3) The *structuring* is an open procedure that describes the assignment of codes to quotations in the descriptive summaries. Codes are utilized to identify similarities and differences in the data across participants, which can lead to distinct themes and patterns within the data set. Codes are developed and (re-) examined in an iterative process.

Coding scheme and inter-rater reliability

An inductive coding scheme was developed that emerged from the data during initial steps of the summarizing and explicating processes of the *Qualitative Content Analysis* (Kohlbacher, 2005; Mayring, 2002). The data-driven, inductive coding scheme (unlike a theory-driven, deductive coding scheme), permitted a careful exploration of epistemic beliefs of the elementary school students without inducing potential biases from existing theories derived from personal epistemology research with adult populations (Bogdan & Biklen,1982). The coding scheme was developed in an iterative process that involved two researchers.

First each researcher developed a separate coding scheme for 20% of the data sets, which were randomly assigned; second, these coding schemes were consolidated and, third, the final coding scheme was defined and operationalized by both researchers together. The different codes and their occurrence across the sample are defined and reported in detail in the result section and summarized at the beginning of the discussion section.

Figure 1: Coding scheme. This figure illustrates the structure and hierarchy of the coding scheme



Finally, the inter-rater reliability was determined to verify the objectivity of the coding scheme. After all data were coded, a second researcher coded 30% of the data sets, which were randomly assigned, to identify the agreement level between the codes that were assigned by both researchers. The calculated Cohen's Kappa (1960), $\kappa = 0.94$, indicated a high agreement between the researchers (i.e., good agreement $\kappa = 0.61$ - 0.80; very good agreement $\kappa = 0.81$ - 1.00). This statistical measure of inter-rater reliability is generally thought to be a more robust measure than simple percent agreement calculation since κ takes into account the agreement occurring by chance.

Software support

All data was recorded and analyzed in the format of digital data files. The software Atlas. ti V7.0 was used to develop the inductive coding scheme, to analyze the data, to establish the interrater reliability, and to retrieve quotations. Atlas.ti is a software tool used to support the analysis of large-scale qualitative data sets. It allows for an efficient, non-automatized workflow of qualitative analysis; that is, researchers are still required to deliberately develop coding schemes, assign code to data, and make decisions at all levels of the data analysis.

5. Results

The result section encompasses several subsections that follow the hierarchical structure of the coding scheme, as depicted in Figure 1. The subsection includes code definitions, code density (i.e., occurrence of codes across participants), and exemplary quotations to illustrate the codes.

5.1 Epistemic beliefs about independent knowledge verification

About half of the participant sample (n = 55) expressed beliefs that were coded as *Beliefs about independent knowledge verification*. Students' were assigned to this code when their strategies on how to scrutinize knowledge could be accomplished without accessing or depending on external knowledge resources, such as parents, teachers, and different media. These beliefs were assigned to the following eight belief sub codes: (1) *Knowledge is verified by its replication* (n = 22); (2) *Knowledge is verified by sensory perception (5 senses)* (n = 21); (3) *Knowledge is verified by investigation* (n = 13); (4) *Knowledge is verified by trial and error* (n = 11); (5) *Knowledge is verified by logical thought* (n = 9); (6) *Knowledge is verified bycomparison to analog knowledge* (n = 5). (7) *Knowledge is verified with evidence (n = 4)*; and (8) *Knowledge is verified bypersonal experience* (n = 1). Note that some students expressed more than one of these beliefs.

Knowledge is verified by its replication

This belief category describes the belief that knowledge can be assessed by replicating the process applied to gain the knowledge under scrutiny. Twenty-two students held this belief. For example, two students explained their approaches: "I can verify what I have thought of by thinking it over for another time. In the second time, I find mistakes which I would not have discovered otherwise. Then I know it for sure." (C9M 10,16) and "To recalculate on your own: it is best to recalculate three times, because one could have calculated wrongly the second time. If two results are right, this then will be the right one." (E4F 11,16 -). Both students emphasize the possibility of verifying knowledge by replicating it at least another time to be able to compare both results or to search for possible flaws. The first student quotation above illustrates that this belief is also found to scrutinize knowledge in general. The second student referred to recalculation of mathematic tasks as repetition. Many students embedded their examples of this category in the domain of mathematics. Some students also mentioned the need to slightly change or reverse the replication technique to verify the results of a mathematic task. Very few of these students (n = 3) also mentioned the additional use of a pocket calculator as part of the replication process (despite the use of a pocket calculator these students were assigned to the *Independent knowledge verification* code because their response focused on repetition and not the medium).

Knowledge is verified by sensory perception (5 senses)

This code described the belief that knowledge can be perceived by sensory perception. Hence, sensory perception, such as vision, hearing, smell, taste, and touch, can be applied to verify the existence and truth of knowledge. Twenty-one students were assigned to this code. Most of them referred to vision, some to touch, and only one student to hearing, for example: "Observation. I have a look on my own." (C8M 10,58 -) and" When I play the violin wrong then my teacher tells me. Most of the time, I hear it on my own when something sounds wrong." (C10M 10,66 +). In these quotations, the first student explicitly expressed observation as one way to verify knowledge, while the other student mentioned hearing as a perception to distinguish whether a note is on pitch or not. Compared to the other six codes, this strategy seemed to be the most cognitive effortless method to scrutinize knowledge. None of these students believed that sensory perception is the only approach to validate knowledge.

Knowledge is verified by investigation

This code encompassed the beliefs of thirteen students who thought that knowledge can be verified in a process of research investigation or experimentation. This belief was also distinct in that it encompassed the notion that more cognitive effort is required to verify knowledge. The following quotations are examples of this category: "I research. I calculate the proportions; have a look at what was wrong, what was programmed wrongly and what has changed at the spaceship.[1]" (I8M 9,58 -) and Sometimes I make experiments, for example. When I want to know if something is dangerous, then I ask my brother or parents first.

[1] Note, instead of providing his own example, this student made use of the interview scaffold, the picture story of the Martian.

If it is not dangerous I will try it on my own to verify if it is correct. If it would be dangerous I would not try it. But then I do not know it either**.** (K3F 10,08 +) In the first quotation, the action undertaken by the student to investigate why the Martian's spaceship crashed was described as doing 'research'. The other student explained in more detail how she implements experiments to verify knowledge, which also indicates a scientific approach. Although, not all students explicitly mentioned research terminology, such as experiments, they all described processes of scientific inquiry to verify knowledge.

Knowledge is verified by trial and error

This code described the belief that knowledge can be scrutinized by testing or applying it. Success and failure were understood as indicators that verify or falsify, respectively, the knowledge under consideration. Eleven students held this belief of trial and error. They explained for example: "One can know if things are correct or are not correct by trying it out. If it does not work then one knows it wrong or one has done it incorrectly." (C6M 10,91 --) and "Regarding bungee jumping I would not try it myself if the rubber holds. I try it out with a heavy stone. If it holds up, and I have the guts, I would jump myself." (E10F 10,91 +). In the quotation of the first student, he mentioned the trial and error approach to investigate the validity of knowledge in general. The second student described in more detail the applied strategy and process that she would use to test knowledge about bungee jumping using a trial and error approach.

Knowledge is verified by logical thought

This code described the belief that knowledge is scrutinized by in a process of pondering and critical thinking. Nine students were assigned to this category. The following two quotations are examples of this code: "I can verify knowledge by thinking. I sit at a place where nobody disturbs me and then I think. Sometimes that is correct." (C9M 10,16 0) and "To puzzle something out with my friend or in a small group. Finding arguments and thinking if it is correct." (I1F 10,16 + +). Both students referred to thinking as an approach to scrutinize knowledge. Cognitive effort was implied in their beliefs when they referred to developing arguments, concentrating on the topic, and not being disturbed when scrutinizing knowledge. Furthermore, it is interesting to note that the first student used logical thought on his own while the second student explained that she and her friends approach the verification of knowledge in a group. Overall, six female and three male students held this belief.

Knowledge is verified by comparison to analog knowledge

This code described the belief that knowledge is scrutinized by comparing it with similar knowledge. Beliefs of five students were assigned to this code. The following two quotes are examples of this belief: "A spaceship accident can also occur like a bus accident can occur. He [the Martian] could have been falling asleep." (A3F 9,83 +) and "I know that the engines [of the spaceship] broke down, because on television often the rocket engines break down." (C7F 10,75 0). Both students believed to verify their assumptions on the spaceship crash by comparing them to existing, similar knowledge, which was not directly related to this particular incident. The first student rationalized her assumption about the crash based on common reasons for bus accidents, while the other student refers to common breakdowns in space travel. All students who held this belief referred to analog knowledge they already knew (prior knowledge). None of them mentioned the need to access an external, additional knowledge resource to gain the required analog knowledge.

Knowledge is verified by evidence

This code described the belief that knowledge claims can be validated with evidence. Four students hold this belief and stated, for example: "The Martian could have crashed for several reasons. For example, something could have been wrong with a meter. I cannot decide on one possibility, because I do not have evidence or a reason and because other things could have happened." (B10F 10,16 ++) and "Maybe the Martian crashed because he lost control. But I cannot be sure. To know it for sure I need evidence." (C3F 10,5 --). The need for evidence is apparent in both of the quotes. Neither of these students seemed to be willing to make final statements about what really happened when the Martian crashed. They believed in evidence as a criterion to determine the truth of a knowledge claim. However, none of these students followed up with a methodological approach, like a scientific investigation, to satisfy their need for evidence.

Knowledge is verified by personal experience

This code described the belief that knowledge is validated by personal experience. In other words, direct participation in an (external) event can verify knowledge. Only one student was assigned to this category. Her answer response was: "My mother says that when one gets an injection at the dentist it does not hurt. I believe her. After I got the injection myself, I know that it does not hurt and that it is correct." (G1F 10 0) Being at the dentist is a personal experience in which the student describes how she verified the fact that injections do not hurt, in that she directly participated in this event: Herself was the person who got the injection that did not hurt.

5.2 Epistemic beliefs about dependent knowledge verification using external sources

In addition to the eight beliefs about independent knowledge verification, seventy-eight students were identified who held beliefs about knowledge verification in which they relied on additional, external resources, and/or prior knowledge. Their answers were assigned to the following three belief categories: (1) *Knowledge is verified by asking* (n = 50); (2) *Knowledge is verified by looking it up* (n = 40); (3) *Knowledge is verified by comparing different sources* (n = 15).

Knowledge is verified by asking

This code described the belief that knowledge can be validated by asking another person. It contains the notion that the person asked is expected to share his/her prior knowledge. Hence, the knowledge of a second person is accessed in order to compare it with the knowledge of the student. If the accessed knowledge is in accordance with what is known, the process of verification might be stopped. If not, a student might access another knowledge resource (e.g., *Knowledge is verified by comparing different resources*). The beliefs of fifty students were assigned to this code. The following quotations are examples of this code: "I ask the teacher or my parents, if things are right." (B10F 10,16 ++) and "I ask my desk neighbor, if it is right." (C3F 10,5 --). In both quotations, it is evident that students used the verbatim construction "to ask" and furthermore that the purpose of asking was to verify "if something is right."

Students also provided a list of persons they would ask to verify knowledge, which were sorted into four sub codes: (1) *Family members*, such as parents, grandparents, and siblings, (2) *Teachers*, (3) *Friends*, and (4) *Others*, such as any person who knows about the topic under scrutiny, the desk neighbor, or a scientist. *Family members* were identified as the most accessible resource to verify knowledge. Twenty-seven students mentioned at least one person that was part of this group. Nineteen students mentioned *Teachers*, and five included *Friends*. Twenty-seven students mentioned a person assigned to the heterogeneous group of *Others*. Some students referred to more than one group in their elaboration of this belief.

Knowledge is verified by looking it up

Students who were assigned to this code believed in accessing a knowledge resource that was not a person/ human. This code also contained the anticipation that the accessed resource might or might not provide knowledge to permit the validation of to the scrutinized knowledge. Forty students held this particular belief. The subsequent quotes illustrate examples for this belief code: "I have a look at books; if it's about plants, in plant books." (G2M 10 -); "I look it up in an encyclopedia. When one writes something on the computer, it underlines what is wrong." (H1F 10,5 +); and "I watch the weather forecast." (E3M 10,25 0). All three students referred to knowledge resources that are not human. Topic specific books, like plant books, and encyclopedia, were accessed to look up information that would verify or further question the existing knowledge. Furthermore, a computer was mentioned as a resource to verify the correctness of a written text, and the weather forecast to verify assumptions about the weather.

These quotations also indicate the diversity of resources accessed to verify knowledge, which were subsequently categories in four sub codes: (1) *Print media*, (2) *Computer and online media*, (3) *Audio-visual media*, and (4) *Educational materials made by the teacher*. Thirty-four students mentioned resources that were categorized as *Print media*, such as books in general, school books, encyclopedias, and newspapers. Nine students referred to *Computer and online media*, such as specific computer software and the World Wide Web, while four students referred to *Audio-visual media*, such as the weather forecast, the news, and a soccer game on television. Only one student referred to worksheets, which were provided by her teacher.

Knowledge is verified by comparing different sources

This code combined two codes: *Knowledge is verified by asking,* and *Knowledge is verified by looking itup*. Hence, students who were assigned to this category believed that knowledge can be verified by accessing and comparing multiple sources to validate knowledge. Most of students counted the number of resources that confirmed the knowledge claim and compared it to the number of sources that refuted or offered other knowledge claims. The highest number of sources would be used to identify what knowledge would be (more) right, while knowledge claims with outnumbered sources was considered as (more) wrong. This belief was found in fifteen students and is evident in the following examples: "If different opinions exist I look it up in the dictionary." (K9M 10,8 +), "My parents and my teacher know the same amount. (…) I look it up in the dictionary or I ask my grandma. The one with whom she agrees, mom or teacher, is the one who is right." (F6F 11 -), and I look it up in specialized books; if it is about mountains, in a book about mountains. One needs to take the age specification of a book into account because in new books is newer knowledge. I ask my parents, ask my teachers. The majority counts: two outvote one. (I5M 10,33 ++)

All three students stressed the need to compare knowledge across different external resources. The first students compared the opinions of other people with the dictionary. The second student believed that the person with whom her grandmother agrees with must be right. The third student looked up knowledge in different specialized books, and asked his parents and teachers. He explicitly emphasized that the majority counts, and, hence, must be right.

5.3 Epistemic beliefs about selection criteria for identifying knowledge sources

Students expressed different rationales why they would access knowledge sources in the process of dependent knowledge verification. Eight different selection criteria were identified: (1) *Certainty of knowledge* (n = 52); (1) *Quantity of knowledge* (n = 50); (3) *Domain-specificity of knowledge* (n = 17); (4) *Age and experience of the knowledge source* (n = 16); (5) *Quality of knowledge* (n = 10); (6) *Proximity of the knowledge source* (n = 7); (7) *Quality of explanation* (n = 4); and (8) *Discreetness of the knowledge source* (n = 4). Students mentioned more than one criterion for selection of knowledge resources.

Certainty of knowledge

Fifty-two students commented on the amount of certainty they can have concerning the correctness of the knowledge provided by a knowledge source. Overall, students believed that all knowledge sources, such as teachers, family members, newspapers, and books, can be mistaken or incorrect, while some might provide more certain and valid knowledge. Most of the students considered their teachers and parents as reliable resources for correct knowledge who, sometimes, also can be mistaken (n = 43, including students who stated that everybody can be mistaken). Three students provided examples for situations when their teachers were mistaken: when reinforcing the new spelling rules (B3M), when checking student attendance (B4F), or when they are too quick in what they say (C1F). In contrary, five students believed that their teachers were always right in what they knew; and five students believed in the absolute certainty of their Parents (G4F), uncle and aunt (C5M), the referee of a soccer game (A5M), the pocket calculator (C10M), and the newspaper (B8F).

Some students ranked the level of certainty of a knowledge source which determined how often they would approach the source strategically to verify their own knowledge. Teachers and parents were about equally mistaken. Compared to these, older siblings were perceived to be more mistaken, followed by the student him/her-self. Younger siblings were hardly asked, as they were believed to be mistaken the most.

Quantity of knowledge

This code described the belief that some knowledge sources contained more comprehensive knowledge than others, but none could provide all existing knowledge. This code was mentioned by fifty students. Sixteen students stated that no person can know everything due to the fact that too much knowledge exists. One student argued that not all knowledge can be known, as there are still too many unknown secrets (F5M). Only two students were found to be an exception by believing that adults do know everything (E5M; H10F). Most commonly, adults were perceived to know more compared to younger people. Sometimes parents were perceived to know more than teachers, sometimes teachers more than parents, and sometimes they were evenly ranked. Grandparents tended to know slightly more than teachers and parents.

Smart people (F4M), such as Einstein (D7M), were believed to know more than the average adult. The participants believed that older siblings knew less than average adults but still more then themselves; younger siblings knew the least. Some students also stated that parents, in particular mothers, needed time to recall their *school* knowledge. This belief was in line with the notion that parents forgot more of their (school) knowledge in comparison to their teachers (A4M; E2F). One student stated that there exists more knowledge online than a single person can ever know (D1W).

Domain-specificity of knowledge

Seventeen students mentioned that they preferred to ask topic related questions only to certain persons. This code was based on the belief that people do know domain-specific knowledge. Examples of this are mentioned in the following quotations: "Who I ask depends on what I want to know." (E9M 11,66-) and "People can know different things." (E6F 10,83). Participants made a clear distinction between *school* knowledge and knowledge relevant in their private life. Students, overall, seemed to ask teachers about knowledge that they learned at school, while they would ask their parents about knowledge which they would considered as private. One student mentioned that she would ask her brothers and friends about knowledge that relates to her spare time (K1F).

Students made also more concise domain-specific distinctions. Some stated that their teachers knew more specific knowledge, while their parents knew more general knowledge (H3F; K3F; K4M). One student mentioned, for example, that she would ask her mother about German, her father about Mathematics, and her brother about soccer (E7F). Another student stated that she would ask her teacher about mathematics and German, her grandparents about history and the war, her aunt about Brazil, and her parents about general things (K3F). Domain-specific knowledge was the only selection criteria for participants to consider their younger siblings as a serious knowledge source. That is, when the younger sibling was perceived as a specialist for a certain knowledge domain: "I know more than my little brother, but he knows more about plants and animals than I do. I would ask him about these topics as well." (I4F 10,33). Interestingly, one student stated that he also knew who he would not ask regarding certain topics; that is, his father about German, because he did *not* know the new spelling rules, and his grandparents about mathematics, because they did not know the mathematical tasks (G7M).

Age and experience of the knowledge resource

The age and/or experience of a knowledge source were also found to be a source selection criterion. Sixteen students believed that the older and/or more experienced a knowledge source is, then the more knowledge it will have accumulate over time compared to other resources and, therefore, provides knowledge that is more accurate. Grandparents were named as a source for this reason. Students referred to them when there is the need to ask somebody who knows more because he/she has lived for a longer time (B7M), someone who has more experiences and lived in different places (D1F), such as a "my grandmother who knows things exactly because she knew about it earlier on and because she is already so old" (E5M 10,25 0). Other students emphasized that persons, such as their parents and older siblings, knew more because they were older and had experienced more in their life.

Quality of knowledge

Ten students mentioned that the quality of knowledge can differ from source to source. This criterion described the rationale that some persons know knowledge better and more precisely than other persons. For example, one student stated: "Children can also know right things like adults. But children do not know it exactly. They know it from the teacher or their parents. It is better to ask the teacher again to make sure that it is correct." (B2W 10,16 +). In this understanding, the teacher is consulted because she was assumed to know better and more precisely than the other children. Teachers were perceived to know things better than parents. Only one student believed that his grandmother knew things better than the teachers. Adults, again, seemed to know things better than children and classmates (C3W). The referee of a soccer match was mentioned as knowing soccer rules the best (C5M). It could be argued that this criterion was driven by an authority belief about knowledge. However, students seemed to be interested in a source who would know knowledge in a more profound way with an understanding of why, that rather than simply signing off to an authority figure. Furthermore, students mentioned the *Proximity of the knowledge source* to determine whom they would ask in order to obtain an answer to their question. Seven students believed that the decision depended on their geographical closeness to the knowledge source: when they are at school, they ask their teachers and when at home, their parents and siblings.

How well a resource is able to present and explain the requested knowledge was referred to as the *Quality of explanation*. Four students mentioned this criterion. Two believed that teachers can explain knowledge better than others, because they know more details about it (I4M), or simply because it is their profession (F3M). In contrast, one student mentioned that his mother is better in explaining things about India than his teacher because she has lived in India herself (B3M), and another student mentioned that her mother takes more time for the explanation than her teacher (B9F). Four students mentioned the ***Discreetness of the*** *knowledge source* as a selection creation. They referred to close family members, their best friends and people they can completely trust as sources. This criterion contained the notion that the source should not share what knowledge was verified when they were approached, but be secretive and/or discreet about the topic.

Overall, it was also evident that some of the criteria beliefs were closely connected with each other. For example, the criterion *Quantity of knowledge* is somewhat interrelated with the criterion *Age and experience ofthe knowledge resource*. This is because the latter also contains the notion that knowledge is accumulated over time. On the other hand, the criteria *Quality of explanation* might be intertwined with *Domain specificity of knowledge*, because the more a person knows about a certain domain, for example, the better the quality might be of the explanation. An example for the interdependence of the criteria became evident when students explained how they would select knowledge sources based on a sequence of criteria.

5.4 Meta-cognitive aspects of epistemic beliefs about selection criteria for knowledge sources

Based on these criteria, students seemed to make conscious choices on what sources to access in what situation to verify knowledge. Some students discussed a hierarchy of criteria to inform the selection of knowledge sources they would access first, second, and third, if a knowledge source would fail to provide the needed information. Students, for example, considered: if a targeted source was not available, did not provide the type and quality of information needed, or turned out not to be as trustworthy as expected. The fourth graders ability to verbally name and identify different criteria to select appropriate knowledge sources demonstrated a meta-cognitive understanding of their knowledge sources; that is, students' knowledge about their own knowledge sources. Furthermore, their ability to systematically prioritize selection criteria to achieve the best possible outcome in their knowledge validation process demonstrated a meta-strategic understanding of knowledge sources; that is, students' knowledge about their own strategies of knowledge verification with external sources. Ten students mentioned meta-strategic process of gradually eliminating knowledge source based on prioritized selection criteria. The following quotation is an example for such a meta-cognitive strategy of source selection:

I have a question and think by myself who could answer it best, that is who I ask, that is who knows most. One cannot say who knows more or who is more mistaken; this depends on the area. My younger brother is sometimes mistaken. I ask him when I cannot ask the others. If he says some things wrong, I am not grumpy because of that. (K3F 10,08 +)

In this quotation, it is evident that the student makes a decision regarding which knowledge source to access. Identifying the sources who might answer the question best, and who knows the most is informed by the *Quality of explanation* and *Quantity of knowledge* criteria. Furthermore, her belief, that people can be mistaken, and that this might relate to their area of knowing is informed by the *Certainty of knowledge* and *Domain specificity of knowledge* criteria. Finally, the *Age and experience of the knowledge source* criterion is applied with respect to the younger brother, who is only asked if older or more experiences people cannot be accessed, which, furthermore, accounts for the *Proximity of the knowledge source* criterion. It became evident that this student followed a mental decision-making tree with the purpose to identify the best possible knowledge source while accounting for the goal and situational context of the knowledge verification process. Certainly, not all students incorporated these criteria in such a complex, mental decision-making tree. However, this quote is a good example to illustrate how much meta-cognitive understanding and effort might be taken under consideration by a fourth grader when selecting knowledge sources in order to achieve a reliable verification of knowledge in any given situation.

6. Discussion

6.1 Summary

Overall, eleven different beliefs about knowledge verification were identified in the data set of fourth grade students (n = 98). These epistemic beliefs were conceptually operationalized in the coding scheme focusing on independent and dependent strategies; the latter requiring external knowledge sources in the verification process and the use of criteria to identify appropriate sources to optimize the verification process, if possible. Eight epistemic beliefs about independent strategies were identified and encompassed: (1) *Knowledge is verified by its replication* (n = 22); (2) *Knowledge is verified by sensory perception (5 senses)* (n = 21); (3) *Knowledge is verified by investigation* (n = 13); (4) *Knowledge is verified by trial and error* (n = 11); (5) *Knowledge is verified by logical thought* (n = 9); (6) *Knowledge is verified by comparison to analog knowledge* (n = 5); (7) *Knowledge is verified by evidence (n = 4)*; and (8) *Knowledge is verified by personal experience* (n = 1). Three epistemic beliefs about dependent strategies were identified and encompassed: (1) *Knowledge is verified by asking* (n = 50); (2) *Knowledge is verified by looking it up* (n = 40); and (3) *Knowledge is verified by comparing different sources* (n = 15). External sources that were mentioned by students in the context of the dependent strategies were categories in human sources, including (1) *Family members* (n = 24), (2) *Teachers* (n = 19), (3) *Friends* (n = 5), and (4) *Others* persons (n = 27), and non-human sources, including (1) *Print media* (n = 34), (2) *Computer and online media* (n = 9), (3) *Audio-visual media* (n = 4), and (4) *Educational materials made by the teacher* (n = 1). Furthermore, eight different criteria were identified that students use to select appropriate knowledge sources: (1) *Certainty of knowledge* (n = 52); (2) Quantity of knowledge(n = 50); (3) *Domain-specificity of knowledge* (n = 17); (4) *Age and experience of the knowledge source* (n = 16); (5) *Quality of knowledge* (n = 10); (6) *Proximity of the knowledge source* (n = 7); (7) *Quality of explanation* (n = 4); and (8) *Discreetness of the knowledge source* (n = 4). Ten students were meta-cognitively aware of these strategies which became evident in the mental decision-trees in their espouse beliefs. Finally, different patterns of epistemic beliefs emerged across the ten sub samples, indicating potential epistemic differences and similarities across the ten classroom populations.

6.2 Epistemic beliefs about strategies, sources, and criteria of knowledge verification

With respect to beliefs about strategies to verify second-hand knowledge, beliefs about independent and dependent strategies differed in the amount of type, but also in their occurrence across the sample. There was more diversity identity in independent strategies (n = 8 code definitions) and less in dependent strategies (n = 3 code definitions). Conversely, dependent strategies appeared to be more prevalent across the sample than independent strategies. This result aligns with the findings of Elder's (2002) study that most students were aware of strategies that were dependent on the use of external sources in the verification process. The focus on external knowledge sources and dependent strategies matches up with lower levels of epistemic development, such as dualism and absolutism (Kuhn, 1999), in which individuals believe that knowledge resides externally and trust the rightness of authorities, such as teachers, school books, and encyclopedias, without doubt.

Beliefs about selection criteria of sources seem to be an inherently logical component of scrutinizing existing knowledge. What constitutes a good source of knowledge or data is often part considered an epistemological aspect of the warrant of an individual argument (Toulmin, 2003) or of axioms of a scientific paradigm (T. Kuhn, 1962). Why is it that assumptions about source criteria have not yet been explored at the individual belief level of (personal) epistemology? One reason could be that epistemic beliefs have mainly been investigated using survey items that tap into more theoretical and espoused beliefs about the nature of knowledge and processes of knowing, rather than using activity-based approaches that would allow the exploration of more applied and enacted epistemic beliefs. It would be more likely for participants to enact and report on source selection criteria when they were to engage in activities that would require them to apply their epistemic beliefs within a specific situational context.

The beliefs of three selection criteria are of particular interest because they are continuously discussed by researchers at the construct level of existing frameworks (Greene, et al., 2008; Hofer & Pintrich, 1997; Murphy, et al., 2007; Schraw & Olafson, 2002). Already in fourth grade, students are aware of the *domain-specificity of knowledge* and use it as a criterion to identify an appropriate knowledge source (Muis, Bendixen, & Haerle, 2006). The selection criterion of *Age and experience* points towards beliefs about wisdom and intelligence that have been researched in neighboring fields (Dweck & Leggett, 1988; Heckhausen, Dixen, & Baltes, 1989; Rowley & Slack, 2009).

The criterion*Quality of explanation* demonstrates that students considered learning from, and/or being taught by, a knowledge source when verifying knowledge, which can be considered as epistemological dimension about learning (Schommer, 1990). The awareness of fourth graders about selection criteria and their ability to speak about conceptual aspects of the construct in an applied and direct manner is remarkable and surprising.

6.3 Complexity of epistemic beliefs

Overall, the identified beliefs about processes of verifying second-hand knowledge were more complex than expected for the age group of fourth grade students. This complexity is driven by the diversity of different beliefs about the verification of second-hand knowledge and the interconnectedness of these beliefs. The visual display of the coding scheme (Figure 1) provides evidence for the complexity: It is a highly-branched tree with beliefs about dependent and independent strategies (n = 11) that are associated with different beliefs about human and non-human knowledge sources (n = 8) and interlaced with beliefs about criteria (n = 8) that informing the selection of strategies and sources based on the context of a situation and/or topic. This complexity can be described as a system of multi-faceted beliefs that is integral part of a larger system of epistemic beliefs. In the US, Elder (2002) and Kittleson (2011) identified similar interconnected belief systems about independent and dependent verification strategies and knowledge sources about the domain of science knowledge. While similar connections were identified between strategies and knowledge sources, the US third graders and fifth graders had less diverse strategy beliefs than the German fourth graders. Together, all three studies amount evidence that elementary school-aged children have more diverse beliefs about the nature of knowing than are accounted for in the dimensional frameworks as they currently exist (Hofer & Pintrich, 1997; Schommer 1990). That is, the two single continua describing the dimensions of justification and sources of knowledge are not multi-faceted enough to describe and explain the epistemic beliefs of elementary school students about knowledge verification (Greene, et al., 2008; Murphy, et al., 2007).

Based on existing developmental assumptions in the field, it seems to be reasonable to acknowledge that the identified epistemic beliefs in the fourth grade students were more complex in their diversity and interconnectedness than developmentally expected. More sophisticated levels of epistemic development are often associated with more elaborate beliefs which imply that beliefs of adults are more diverse and interconnected than those of children (Perry, 1970; King & Kitchener, 1994). This study provided evidence that the level of complexity cannot necessarily be associated with more advanced developmental stages of personal epistemology. For example, a fourth grader might have a complex system of epistemic beliefs about knowledge verification that can be considered structurally elaborated in its differentiation of strategies, knowledge sources, and selection criteria, but not developmentally sophisticated enough to identify the epistemic nature of an ill-structured problem, such as estimating the truth value of competing knowledge claim, like a person with advanced reflective judgment (King & Kitchener, 1994) or evaluativist understanding of knowledge (D. Kuhn, 1999) would demonstrate.

6.4 Epistemic beliefs as a component of higher-order thinking within a situational context

A second issue revolves around the question if epistemic beliefs are part of cognition or meta-cognition and matters to all types of frameworks in the field of personal epistemology research (Mason & Bromme, 2009). The epistemic beliefs identified in this study provide initial evidence that fourth grade students' epistemic beliefs are located at levels of first-order and higher-order of thinking. I argue that the epistemic beliefs about verification strategies and knowledge sources are located at the first-order level of cognition. These beliefs demonstrate that students have a) procedural knowledge of justification strategies, like looking things up, trial and error, and asking a question, and b) declarative knowledge of knowledge sources, like books, parents, and teachers. Because this knowledge is not about cognition or cognitive operations, it is located at the first-order level of cognition (Flavell, 1979; Schraw & Moshman, 1995). This interpretation aligns with the conceptual propositions of Hofer (2004), Kitchener (1983), and D. Kuhn (1999). Beliefs about selection criteria of knowledge sources seem to be of a different nature. These espoused beliefs seem to influence students' decision making about what sources and strategies to use and how to combine them to ensure best possible outcomes of the knowledge verification processes.

Following a mental decision tree, students (n = 10) in this study identified and ranked sources based on eight different criteria that accounted for the type of knowledge to be verified (e.g., knowledge about the English language, Science, and personal matters), idiosyncratic source characteristics (e.g., amount of knowledge, ability to explain, certainty of knowledge), and source accessibility and situational context (e.g., distance to source and availability at the time of verification). Students seem to use cognitive decision trees to actively reflect, monitor, and regulate the use of strategies and knowledge sources in situational contexts when engaging in the cognitive process of verifying knowledge. I argue that this cognitive process can be conceptually located at higher-order of cognition because it is cognition about cognition (Flavell, 1979; Schraw & Moshman, 1995).

Furthermore, I argue that this form of higher-order cognitive process or decision tree is epistemic in nature because a) it was conceptually embedded in students' epistemic beliefs about second-hand knowledge verification and it was specifically triggered when students began to verbalize their epistemic beliefs about verification strategies and knowledge sources. Therefore, this higher-order cognitive process can be conceptualized as 'epistemological metacognition' (Hofer, 2004) and 'epistemic meta-knowing' (D. Kuhn, 2000) at the second-order of thinking, respectively, or as 'epistemic cognition' (Kitchener, 1983) at the third-order of thinking.

Finally, I argue that the epistemic beliefs about source selection criteria are dependent on the situational context in which knowledge is being verified. To provide a clear example, seven students mentioned the criterion *Proximity of the knowledge source* when selecting a knowledge source. That is, their source choice depended on the geographical location of the source, the distance to the source, and the current timely availability of the sources. For example, in the situational context of being at home after school students would not consider a teacher as a knowledge source to verify knowledge because a teacher would be at a more distant location than their parents. This epistemic belief indicates that students have an epistemic awareness of the situational context (i.e., time and location) when they reflect and regulate the process of knowledge verifications. This cognitive awareness, I argue, provides initial evidence that epistemic beliefs about source selection criteria are sensitive to the situational context of a person who is verifying knowledge and potentially permit a person to flexibly adjust verification strategies and knowledge sources to the situational context by the means of higher order thinking. This conclusion would mean that the situational context, as proposed by in Hammer and Elby's (2002) contextual framework, plays a more important role than it has been acknowledged by other frameworks.

7. Conclusion

From a conceptual perspective, the complexity of elementary school children's epistemic beliefs has been underestimated in the field of personal epistemology. That is, the identified diversity and interconnectedness of epistemic beliefs about the verification of second-hand knowledge, knowledge sources, and criteria for selecting sources can only be partially described and explained by existing frameworks. This is not surprising as most frameworks have emerged predominantly from research with adolescent and adult populations. In particular, dimensional frameworks (Hofer & Pintrich, 1997; Schommer, 1990) seem to be hard-pressed to describe and explain the findings of this study beyond the two-dimensional conceptualization of beliefs about the *Nature of knowing* (Greene, et al., 2008; Murphy, et al., 2007).

Furthermore, systematic research is needed to provide insight into the role of epistemic beliefs at the first and higher-order levels of thinking. In particular, how epistemic beliefs about source selection criteria permit higher-order thinking processes to be sensitive to different situational context, to navigate different knowledge-domains, and to respond to different levels of task complexity. From a methodological perspective, more and better assessment tools are needed that are sensitive to children's personal epistemology and that are open-ended enough to capture variations and complexity of epistemic beliefs beyond the conceptualizations of the existing frameworks. That is, researchers ought to be aware of the limited explanatory power of existing frameworks when they develop measurement and conduct research studies. If not, they will not be able to discover a more complex and multi-faceted construct of personal epistemology than the existing frameworks let them imagine.

From an educational perspective, this study has provided important evidence that elementary school children are capable of using more complex beliefs systems to inform their knowledge verification processes at a first and higher-order level of thinking. Educational materials and instructional approaches should be developed to enable teachers to foster epistemic beliefs in students that permit them to independently verify existing knowledge and to flexibly adjust their cognitive processes based on the task complexity and situational context.

These materials need to be adaptable for easy integration by teachers into their everyday teaching practices and be tested by educational researchers for their effectiveness in authentic classroom settings. The implementation of these conceptual, methodological, and educational implications will allow young citizens to become even more competent users of the existing knowledge they are exposed to in our knowledge convoluted world of knowing (Thinking Habitats, 2016, 2017).

8. References

Ashwill, M. A. (1999). *The educational system in Germany: Case study findings*. Washington, DC: National Institute on Student Achievement, Curriculum, and Assessment. (ERIC Document Reproduction Service No. ED430906).

Astington, J. W., Pelletier, J., & Homer, B. (2002). Theory of mind and epistemological development: The relation between children's second-order false-belief understanding and their ability to reason about evidence. *New Ideas in Psychology, 20(2-3)*, 131-144.

Baxter Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development*. San Francisco, CA: Jossey-Bass.

Bogdan, R., & Biklen, S. (1982). Qualitative research for education: An introduction to theory and methods. Boston: Allyn and Bacon.Brophy, J. E., & Good, T. (1986). Teacher behavior and student assessment. In M. Wittrock (Ed.), *Handbook of Research on Teaching* (3rd ed.) (pp. 328-375). New York, NY: Macmillan.

Bromme, R., Pieschl, S., & Stahl, E. (2009). Epistemological beliefs are standards for adaptive learning: a functional theory about epistemological beliefs and metacognition. *Metacognition and Learning, 5*(1), 7-26. doi: 10.1007/s11409-009-9053-5

Burr, J. E., & Hofer, B. K. (2002). Personal epistemology and theory of mind: Deciphering young children's beliefs about knowledge and knowing. *New Ideas in Psychology, 20*, 199-224.

Chandler, M., Boyes, M., & Ball. L. (1990). Relativism and stations of epistemic doubt. *Journal of Experimental Child Psychology, 50*, 370-395.

Cohen, J. A. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement,20*, 37–46.

Cohen, L., Manion, L. & Morrison, K. (2000). Research Methods in Education (5th ed.). London, UK: RoutledgeFalmer.

Duell, O. K., & Schommer-Aikins, M. (2001). Measures of People's Beliefs About Knowledge and Learning. *Educational Psychology Review, 13*(4), 419-449. doi: 10.1023/a:1011969931594

Dweck, C. S., & Leggett, E. S. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, 95, 256-273.

Elby, A., & Hammer, D. (2010). Epistemological resources and framing: A cognitive framework for helping teachers interpret and respond to their students' epistemologies. In L. D. Bendixen & F. C. Feucht (Eds.), *Personal Epistemology in the Classroom. Theory, Research, and Implications for Practice* (pp. 409-434). New York, New York: Cambridge University Press.

Elder, A. D. (2002). Characterizing fifth grade students' epistemological beliefs in science. In B. K. Hofer & P.R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 347-363). Mahwah, NJ: Lawrence Erlbaum Associates.

Glaeser, J. & Laudel, G. (1999). *Theoriegeleitete Textanalyse? Das Potential einer variablenorientierten qualitativen Inhaltsanalyse* [*Theory guided text analysis. The potential of a variable-oriented qualitative content analysis.*]. Berlin, Germany: Wissensschaftszentrum Berlin für Sozialforschung GmbH.

Haerle, F. C., & Bendixen, L. D. (2008). Personal epistemology in elementary classrooms: A conceptual comparison of Germany and the United States and a guide for future cross-cultural research. In M. S. Khine (Ed.), *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures* (pp. 165-190). Dordrecht, Netherlands: Springer.

Heckhausen J., & Dixon, R. A., & Baltes, P. B. (1989). Gains and losses in development throughout adulthood as perceived by different adult age groups. *Developmental Psychology, 25 (1)*, 109–121. doi: 10.1037/0012-1649.25.1.109

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Educational Psychology Review, 13*, 353-383.

Hofer, B. K. (2004). Epistemological Understanding as a Metacognitive Process: Thinking Aloud During Online Searching. *Educational Psychologist, 39*(1), 43-55. doi: 10.1207/s15326985ep3901_5

Hofer, B. K. (2004). Exploring the dimensions of personal epistemology in differing classroom contexts: Student interpretations during their first year of college. *Contemporary Educational Psychology, 29*, 129-163.

Hofer, B. K. (2006). Beliefs about knowledge and knowing: Integrating domain specificity and domain generality: A response to Muis, Bendixen, and Haerle (2006). *Educational Psychology Review, 18*(1), 67-76. doi: 10.1007/s10648-006-9000-9

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*, 88-140.

Hofer, B. K., & Pintrich, P. R. (Eds.). (2002). *Personal epistemology: The psychology of beliefs about knowledge and knowing*. Mahwah, NJ: Lawrence Erlbaum Associates.

Kardash, C. M, & Howell, K. L., (2000). Effects of epistemological beliefs and topic-specific beliefs on undergraduates cognitive and strategic processing of dual-positional text. *Journal of Educational Psychology, 92*, 524-535.

King, K. S., & 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). Mahwah, NJ: Lawrence Erlbaum Associates.

King, P. M., & Kitchener, K. S. (1994). *Developing reflective judgment*. San Francisco, CA: Jossey-Bass.

Kohlbacher, Florian (2005). The Use of Qualitative Content Analysis in Case Study Research [89 paragraphs]. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 7(1), Art. 21. Retrieved July 21, 2007, from http://www.qualitative-research.net/fqs-texte/1-06/06-1-21-e.htm

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). Mahwah, NJ: Lawrence Erlbaum Associates.

Kuhn, D. (1991). The skills of argument. New York, New York: Cambridge University Press.

Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher, 28*(2), 16-46. doi: 10.3102/0013189X028002016

Kuhn, D. (2000). Metacognitive development. *Current Directions in Psychological Science, 9*(5), 178-181.

Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development, 15*, 309-28.

Kuhn, T. S. (1962). The Structure of Scientific Revolutions. Chicago, IL: University of Chicago Press.

Louca, L., Elby, A., Hammer, D., & Kagey, T. (2004). Epistemological resources: Applying a new epistemological framework to science instruction. *Educational Psychologist, 39(1)*, 57-68.

Mason, L., & Bromme, R. (2009). Situating and relating epistemological beliefs into metacognition: studies on beliefs about knowledge and knowing. *Metacognition and Learning, 5*(1), 1-6. doi: 10.1007/s11409-009-9050-8

Mayring, P. (2002). *Einführung in die qualitative Sozialforschung, Eine Anleitung zu qualitativem Denken [Introduction to qualitative social research. Guidelines for qualitative thinking]*, 5th edition. Weinheim, Germany: Beltz.

Mertens, D. M. (1998). *Research Methods in Education and Psychology: Integrating Diversity.* Thousand Oaks, CA: Sage.

Noak, E. G. (1999). *Comparing U.S. and German Education: Like apples and sauerkraut*. *Phi Delta Kappan, (80)10*, 773-76.

Perry, W. G. Jr. (1970). *Forms of intellectual and ethical development in the college years: A scheme.* New York: Holt, Rinehart and Winston.

Pintrich, P. R. (2002). Future challenges and directions for theory and research on personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.) *Personal epistemology: The psychology of beliefs about knowledge and knowing*, (pp. 389-414). Mahwah, NJ: Lawrence Erlbaum Associates.

Rosenberg, S., Hammer, D., & Phelan, J. (2006). Multiple epistemological coherences in an eighth-grade discussion of the rock cycle. *The Journal of The Learning Sciences, 15*(2), 261-292.

Rowley, J., & Slack, F. (2009). Conceptions of wisdom. *Journal of Information Science, 35 (1),* 110–119. Doi: 10.1177/0165551508092269

Ryu, S., & Sandoval, W. (2012). Improvements to elementary children's epistemic understanding from sustained argumentation. *Science Education, 96*(3), 488-526. doi: DOI 10.1002/sce.21006

Sandoval, W. A., & C¸am, A. (2011). Elementary children's judgments of the epistemic status of sources of justification. *95*, 383 - 408. doi: 10.1002/sce.20426

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82*, 498-504.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology, 84*, 435-443.

Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the Embedded Systematic Model and coordinated research approach. *Educational Psychologist, 39(1),* 19-29.

Schommer-Aikins, M., Duell, O. K., & Hutter, R. (2005). Epistemological Beliefs, Mathematical Problem-Solving Beliefs, and Academic Performance of Middle School Students. *The Elementary School Journal, 105(3),* 289-304.

Schraw, G. (2013). Conceptual Integration and Measurement of Epistemological and Ontological Beliefs in Educational Research. *ISRN Education, 2013*, 19. doi: 10.1155/2013/327680

Schraw, G., & Olafson, L. (2002). Teacher's epistemological worldviews and educational practices. *Issues in Education, 8(2),* 99-148.

Titscher, S., Meyer, M., Wodak, R., & Vetter, E. (2000). Methods of text and discourse analysis. London, UK: Sage.

Thinking Habitats (2016). *Getting ready for civic responsibilities. A college, career, and civic readiness series*. Retrieved from: http://www.thinkinghabitats.com/blog/getting-ready-for-the-three-c-s-to-start-a-successful-life

Thinking Habitats (2017). *From college to career to citizenry. A college, career, and civic readiness series*. Retrieved from: http://www.thinkinghabitats.com/blog/from-college-to-career-to-citizenry

Toulmin, S. E. (2003). *The Uses of Argument* (updated ed.). New York, NY: Cambridge University Press.

Wildenger, L. K., Hofer, B. K., & Burr, J. E. (2010). Epistemological development in very young knowers. In L. D. Bendixen & F. C. Feucht (Eds.), *Personal Epistemology in the Classroom. Theory, Research, and Implication for Practice.* (pp. 220-257). New York, New York: Cambridge University Press.

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. doi: 10.1007/s10648-006-9003-6.

Greene, J. A., Azevedo, R. A., & Torney-Purta, J. (2008). Modeling Epistemic and Ontological Cognition: Philosophical Perspectives and Methodological Directions. *Educational Psychologist, 43*(3), 142-160.

Bendixen, L., & Hartley, K. (2003). Successful learning with hypermedia: The role of epistemological beliefs and metacognitive awareness. *Journal of Educational Computing Research, 28*(1), 15-30.

Brownlee, J., Schraw, G., Berthelsen, D. (2011). *Epistemic eliefs and Teacher Education*. New York, NY: Routledge.

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

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*(10), 906-911.

Flavell, J.H. (1999). Cognitive development: Children's knowledge about the mind. Annual Review of Psychology, 50, 21-45.

Schraw. G., & Moshman. D. (1995). Metacogniuvc theories. *Educational Psychology* Review, 7, 351-371.

Moshman, D. (1998). Cognitive development beyond childhood. In W. Damon (Series Ed.) & D. Kuhn & R. Siegler (Vol. Eds.), *Handbook of child psychology: Vol II. Cognition, perception, and language* (pp. 947-978). New York, NY: Wiley.

Inhelder, B. & Piaget, J., (1958). *The Growth of Logical Thinking from Childhood to Adolescence*. New York, NY: Basic Books.

Khine, M. S. (2008). *Knowing, Knowledge and Beliefs: Epistemological Studies across Diverse Cultures*. Dordrecht, Netherlands: Springer.

Kitchener, K. S. (1983). Cognition, metacognition, and epistemic cognition. Hu*man Development, 26,* 222–232.

Kittleson, J. M. (2011). Epistemological beliefs of third-grade students in an investigation-rich classroom. *Science Education, 95*(6), 1026-1048. doi:10.1002/sce.20457.

Kultusminsterkonferenz [KMK] (2013, May 02). *The Education System in the Federal Republic of Germany*. Retrieved from: http://www.kmk.org/information-in-english/the-education-system-in-the-federal-republic-of-germany.html.

Murphy, P. K., Alexander, P. A., Greene, J. A., & Edwards, M. N. (2007). Epistemological threads in the fabric of conceptual change. In S. Vosniadou (Ed.), *Reframing the conceptual change approach in learning and instruction* (pp. 105–122). New York. NY: Elsevier Press.

Common Core State Standards Initiative (2013, May 02). Mission Statement. Retrieved from: http://www.corestandards.org/

Achieve, Inc. (2013, May 02). Next Generation Science Standards. Retrieved from: http://www.nextgenscience.org/

Kultusminsterkonferenz [KMK] (2004). Bildungsstandards der Kultusministerkonferenz. Erläuterungen zur Konzeption und Entwicklung [National Curriculum Standards. Elaborations on the Framework and Development]. Retrieved from: http://www.kmk.org/fileadmin/veroeffentlichungen_beschluesse/2004/2004_12_16-Bildungsstandards-Konzeption-Entwicklung.pdf.

Yang, F. Y., & Tsai, C. C. (2010). An epistemic framework for scientific reasoning in informal contexts. In L. D. Bendixen& F. C. Feucht (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice* (pp. 124–162). Cambridge, MA: Cambridge University Press

Qian, G., & Pan, J. (2002). A comparison of epistemological beliefs and learning from science text between Americanand Chinese high school students. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 389–414). Mahwah, NJ: Lawrence Erlbaum Associates.

Trautwein, U., & Luedtke, O. (2007). Students' self-reported effort and time on homework in six school subjects: between-student differences and within-student variation. *Journal of Educational Psychology, 99*, 432e444.

Hammer, D. M., & Elby, A. (2002). On the form of a personal epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal Epistemology: The Psychology of Beliefs about Knowledgeand Knowing* (pp. 169-190). Mahwah, NJ: Lawrence Erlbaum.