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The differential development of epistemic beliefs in psychology and computer science students: A four-wave longitudinal study

Tom Rosman [a, *], Anne-Kathrin Mayer [a], Martin Kerwer [a], Günter Krampen [a, b]

[a] Leibniz Institute for Psychology Information (ZPID), Universitaetsring 15, D-54296 Trier, Germany
[b] University of Trier, Universitaetsring 15, D-54296 Trier, Germany

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ABSTRACT

This article analyses the differential development of discipline-specific epistemic beliefs (i.e., beliefs about the nature of knowledge) in computer science and psychology. With regard to computer science, a "hard" discipline, we expected absolute beliefs (knowledge as objective "truths") to increase over time. In contrast, in the more "soft" discipline of psychology, we expected absolute beliefs to be low and stable, and multiplistic beliefs (knowledge as subjective "opinions") to follow an inversely U-shaped trajectory. Hypotheses were tested in a three-semester long four-wave study with 226 undergraduates. Data were analysed by multi-group growth modelling for parallel processes. In computer science, absolute beliefs indeed increased over the study period. In psychology, an initial increase in multiplistic beliefs was followed by a steep decrease. We therefore suggest that epistemic "sophistication" should be conceived of as a flexible adaptation of epistemic judgments to the characteristics of specific contexts, and not as a generalized developmental sequence.

1. Introduction

Beliefs about the nature of knowledge in a certain academic discipline will likely influence learning and information processing of those studying that discipline. Since Perry introduced his *scheme of the intellectual and ethical development* in 1970, such beliefs have been investigated under the term epistemic (or epistemological) beliefs. A growing body of literature emphasizes positive effects of more "sophisticated" epistemic beliefs on information processing (e.g., Kardash & Howell, 2000), learning (e.g., Cano, 2005; Mason, Ariasi, & Boldrin, 2011), and academic achievement (e.g., Schommer, 1993).

What constitutes "sophisticated" beliefs, in contrast, has been subject to much debate. More traditional approaches almost exclusively view high absolute beliefs (i.e., a view of scientific knowledge as an accumulation of certain facts and absolute truths) as obstructive for learning (Hofer & Pintrich, 1997; Kuhn & Weinstock, 2002). In contrast, multiplistic beliefs (i.e., a view of scientific knowledge as tentative, evolving, and personally constructed) are deemed sophisticated and thus beneficial. Research has repeatedly challenged this assumption (Bromme, Kienhues, & Porsch, 2010; Elby & Hammer, 2001; Elby, Macrander, & Hammer, 2016; Muis & Franco, 2010). For example, Elby and Hammer stress that it strongly depends on the discipline in question whether one may see a certain type of belief as *correct* (i.e., espoused by experts in that particular discipline) and *productive* (i.e., facilitating learning).

Longitudinal studies might shed light on such disciplinary differences regarding epistemic beliefs changes, which also allows making inferences about what constitutes a "sophisticated" set of beliefs in a certain discipline. Unfortunately, even though a significant part of epistemic belief research was initially founded on longitudinal data (e.g., Baxter Magolda, 1992; Perry, 1970; Schommer, 1993), such studies have become rare lately. Moreover, we are not aware of any longitudinal studies that explicitly investigated the role of disciplinary differences in the development of epistemic beliefs. This is striking since especially newer approaches posit epistemic beliefs to be shaped by students' instructional environment (i.e., the TIDE framework; Muis, Bendixen, & Haerle, 2006; Muis, Trevors, Duffy, Ranellucci, & Foy, 2015). The present article therefore analyzes the following research questions: How do discipline-specific epistemic beliefs of students from two exemplary disciplines (psychology and computer science) differ at the beginning of their studies, and how do

* Corresponding author.
E-mail address: rosman@zpid.de (T. Rosman).

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these beliefs subsequently evolve longitudinally?

1.1. Theoretical concepts

Kuhn and Weinstock (2002) conceive the development of epistemic beliefs as a sequence of three stages. Development begins in a stage called absolutism, in which individuals conceptualize knowledge in dualistic, absolute contrasts (e.g., right-and-wrong or truth-and-untruth; Kuhn & Weinstock, 2002). Once this view of certain and absolute knowledge is dismissed, the model posits that individuals move on to a stage called multiplism. Individuals holding multiplistic beliefs stress the subjectivity of knowledge and expect different opinions to be equally valid and exchangeable. In its extreme form, sometimes called *radical subjectivity* (Hofer & Pintrich, 1997), they devaluate science as a whole since they expect laypersons' opinions to be just as valid as scientific findings. In the final stage, called evaluativism, individuals acknowledge that truth depends, to a large extent, on the issue in question and on its context. They thus compare, evaluate and weigh different positions to issues and try to integrate conflicting points of view.

Even though Kuhn and Weinstock's (2002) model has become well-established in the literature, one may criticize it for positing a fixed developmental sequence. In fact, already in 2001, Elby and Hammer argued that it strongly depends on the issue in question whether a certain belief type might be seen as *correct* (i.e., according to an expert consensus) and *productive* (i.e., beneficial for learning). Take, for example, rapper B.o.B, who doubts that the earth is round (Brait, 2016). According to more traditional approaches, this would be classified as a multiplistic and thus rather "sophisticated" belief. Nevertheless, not only is this belief incorrect according to a vast majority of astrophysicists; it might also make it harder for B.o.B to study for a geography test. Laboriously weighting the pros and cons of the earth being round, which is deemed a core component of evaluativism, might not be that productive either. In contrast, just accepting the earth being round as an absolute truth can very well be seen as both productive and correct (Elby & Hammer, 2001). In this instance, absolute beliefs would thus be the most advanced belief type, which is not compatible with Kuhn and Weinstock's (2002) assumption of a sequential development over time. More recent research has formulated similar arguments (e.g., Bromme, Kienhues, & Stahl, 2008; Bromme et al., 2010).

Bromme et al. (2010) further substantiate this point of view by arguing that due to the uneven distribution of knowledge in our societies, many claims *can* only be evaluated by specialized experts (since laypersons simply lack the necessary prior knowledge). Evaluativistic beliefs would thus be unsuited in many situations. Determining the trustworthiness of an expert and subsequently adopting this experts' judgment (which is a central component of absolutism), in contrast, might be more "advanced" than an evaluative approach. In addition, Muis and Franco (2010) argue that learning is facilitated when the epistemic nature of a learning task corresponds with the individual epistemic beliefs of a person (so-called *consistency hypothesis*). A development towards consistency between an individual's beliefs and the epistemic nature of a learning task (or the typical learning tasks in a particular discipline) might thus be preferable over the fixed sequence suggested by Kuhn and Weinstock (2002).

1.2. Epistemic beliefs in psychology and computer science

The Theory of Integrated Domains in Epistemology (TIDE) posits that even though general (i.e., discipline-unspecific) epistemic beliefs are intertwined with discipline-specific beliefs, the latter become more influential throughout education (Muis et al., 2006; 2015). Accordingly, research has found both inter-individual (e.g., Paulsen & Wells, 1998) and intra-individual (e.g., Stahl & Bromme, 2007) differences in epistemic beliefs pertaining to different disciplines.

To categorize academic disciplines, researchers often refer to Biglan's (1973) classification scheme, in particular to the dimensions *hard/soft* (i.e., existence of a unified paradigm or not) and *pure/applied* (i.e., focusing on theory vs. on practice). Even though a specific classification might not apply to all facets of the respective discipline (Muis et al., 2006), research shows that the scheme is surprisingly persistent (Stoecker, 1993), even half a century later (Simpson, 2015).

Knowledge structures strongly differ depending on whether a unified paradigm exists in a specific discipline or not (Muis et al., 2006). Given that a discipline's knowledge structure likely explains a considerable amount of variance in students' conceptions of that knowledge, Biglan's (1973) first dimension (hard/soft) seems particularly relevant in research on epistemic beliefs. To avoid bias, we further argue that when empirically contrasting two disciplines, they should primarily differ in one of the two dimensions. Contrasting physics (hard and pure; Simpson, 2015) and psychology (soft and applied; Simpson, 2015) might thus be problematic since one does not know to which of the two dimensions potential differences in epistemic beliefs may actually be traced back to. In line with both these arguments, we chose to analyze epistemic belief development in two prototypical disciplines that primarily differ in Biglan's (1973) first dimension: Psychology, which is assumed to be soft and applied, and computer science, which in turn is considered hard and applied (Simpson, 2015).

In computer science, knowledge can be conceptualized as more "absolute" than in softer disciplines. In fact, computer science has a strong focus on applied mathematics (Association for Computing Machinery & IEEE Computer Society, 2013), thus allowing that "the parameters of the problems can be specified with a high degree of certainty and … deductive logic and complex, logical manipulations are central tools of the discipline" (King, Wood, & Mines, 1990, p. 170). Therefore, due to its highly formalized and axiomatic structures, computer science is often described as *well-defined* (King et al., 1990). According to the consistency hypothesis[1] by Muis and colleagues (e.g., Franco et al., 2012; Muis & Franco, 2010), absolute beliefs will thus be *productive* (i.e., facilitate learning) in computer science because many learning tasks in that discipline have a more absolute epistemic nature. This is in line with Elby and Hammer's (2001) argument that absolute beliefs are productive with regard to complex and counterintuitive learning contents in introductory physics (e.g., Newton's laws). Moreover, given the strongly formalized structure in hard sciences and the relatively large consensus on what constitutes accepted proofs and theorems (King et al., 1990; Muis et al., 2006), absolute beliefs might also be more *correct* in computer science, especially when compared to soft sciences. We therefore expect computer science students to have higher absolute beliefs than students from "softer" sciences (e.g., psychology). Evidence for this expectation comes from King et al. (1990), who found that students majoring in computer science, applied mathematics, or pure mathematics had stronger absolute beliefs than students from psychology or sociology. Further corresponding evidence can be found in a small-scale qualitative interview study by Whitmire (2003).

[1] We acknowledge that the consistency hypothesis is based on a different theoretical approach than the one of the present article (i.e., on the work by Royce [1978]). Due to its intuitive plausibility and clear theoretical rationale, we nevertheless think that it is worthwhile to further apply its assumptions to Kuhn and Weinstock's (2002) approach.