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A Role for Epistemic Insight in Attitude and Belief Change? Lessons from a Cross-curricular Course on Evolution and Creation

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Abstract
This paper presents findings from a quasi-experimental study evaluating future teachers' attitudes and beliefs in response to a cross-curricular university course on evolution and creation bridging biological and Christian theological perspectives. Based on previous findings, we hypothesized that a course providing learning opportunities for epistemic insight within this multidisciplinary arena might have effects on attitudes and beliefs relevant to the field. Hence, the main research question was the following: To what extent do student teachers' attitudes and beliefs change by attending a cross-curricular course on evolution and creation intended to develop student teachers' epistemic insight into the nature of science and into the relationship between science and theology? The answer from this quasi-experimental evaluation study (pre–post-design; test group $n = 26$, control group $n = 24$) is as follows: It depends upon the variable investigated! Pre–post-analysis using a repeated measures ANOVA revealed that the cross-curricular course integrating epistemic insight induced changes in creationist beliefs, in students' perception of conflict, and in acceptance of evolution. In contrast, there was no effect on attitudes toward evolutionary theory, on attitudes toward the Biblical accounts of creation, or on scientistic beliefs. However, when student responses were analyzed individually, case-based evidence for belief change in students with scientistic positions emerged. Among the reasons for those different effects, we discuss conceptual differences between attitude and acceptance, features of the student teacher sample, and the particular content of the course explicitly addressing creationism but not scientism. In conclusion, the paper corroborates the role of epistemic insight in the multidisciplinary field of evolution and creation and provides initial evidence that epistemic insight possesses a particular potential concerning positions at both ends of the spectrum.

Keywords Attitudes toward evolutionary theory · Attitudes toward the Biblical accounts of creation · Creationism · Scientism · Science and religion issues · Cross-curricular approach

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Introduction

Epistemic insight, understood as knowledge about knowledge and how knowledge of one discipline relates to other disciplines (Billingsley 2017), is considered central to the evolution/creation controversy. In particular, there is a significant body of research on the impact of understanding the nature of science (NOS)—one feature of epistemic insight related to science—on acceptance of evolutionary theory (e.g., Dagher and BouJaoude 2005; Cofré et al. 2017a; Cofré et al. 2017b; Lombrozo et al. 2008). Further, it has been argued that epistemic insight into the relationship between science and religion helps reduce the perception of conflict between science and religion. More precisely, scholarly accounts of how science and religion may be seen as compatible tend to be quite sophisticated, requiring a high level of what has recently been labeled epistemic insight (Billingsley et al. 2013; Taber et al. 2011). Consequently, epistemic insight might help to develop non-conflicting views and thus prevent extreme positions in the field of evolution and creation.

The present paper reports on findings from an evaluation study of a cross-curricular university course on evolution and creation for future primary and secondary school teachers. The findings provide information on the role of epistemic insight for at least three reasons. First, bridging biological and Christian theological perspectives on the issue, the cross-curricular course presents an opportunity to learn about (the nature of) science within a wider context. Second, by explicitly discussing the relationship between science and religion[1] as well as their epistemic underpinnings, epistemic insight becomes an essential component of the course. Third, the findings we report in this paper do not focus on acceptance of evolution only but on five additional attitude constructs relevant to the field of evolution and creation. In brief, the present paper aims to contribute to a more differentiated understanding of the effects associated with epistemic insight in the field of evolution and creation.

Theoretical Background

Epistemic Insight

Epistemic insight is a relatively new term combining different research traditions. In brief, epistemic insight denotes knowledge about knowledge, views on how knowledge and scholarship work and, in particular, knowledge about disciplines and how they interact (Billingsley 2017; Billingsley et al. 2013). Hence, epistemic insight can be considered an umbrella term for research on epistemological beliefs, on knowledge and beliefs about the nature of science, and on ways of relating science and religion/theology. More precisely, epistemological beliefs refer to general beliefs about knowledge and knowing (Hofer and Pintrich 1997), while the expression "*nature of science*" refers to more discipline-specific beliefs about scientific knowledge and knowledge production in science (Neumann and Kremer 2013). Ways of

[1] From a scholarly point of view, it would be more precise to use the term "science and theology" instead of "science and religion," indicating that the two scholarly disciplines act on the same level. This does not imply that "religion" is not a scholarly discipline, but that it usually refers to the study of religion as an anthropological or sociological phenomenon rather than studying the particular beliefs and doctrines which usually make up the study of theology. Importantly, the term science and religion is far more commonly used. Consequently, we decided to use the more common term within the theoretical background linking this study to previous research, but to use the more precise term in the scientific accompanying research.

relating science and religion are often described in line with Barbour's (1990) fourfold typology of conflict, dialogue, or independence. Epistemic insight is differentiated from other established concepts in that it includes is that it includes both general, subject-independent beliefs (i.e., epistemological beliefs), knowledge about specific disciplines (e.g., knowledge about the nature of science), and knowledge about how different disciplines interact (e.g., science and religion/theology or science and the humanities). In particular, epistemic insight is a broader construct than NOS, not only focusing on the nature of the respective disciplines but also looking at what makes science distinctive (Billingsley and Hardman 2017).

Attitudes and Beliefs Concerning Evolution and Creation

The present paper is based on psychological definitions of attitudes, beliefs, and acceptance. In social psychology, an attitude is defined as a summary evaluation of an attitude object, that is, a person, object or idea (Bohner and Wänke 2002; Smith and Mackie 2007). According to the multicomponent model, an overall evaluation may encompass cognitive, affective, and behavioral components (Eagly and Chaiken 1993). From this perspective, beliefs are conceptualized as the cognitive foundation of an attitude (Stürmer 2009). For instance, a positive attitude toward evolutionary theory is an overall positive evaluation of evolutionary theory which may be based on positive beliefs (e.g., *important*, *relevant*), positive feelings (e.g., *interesting*, *exciting)* as well as associated behaviors (e.g., *watch a film on evolution*, *visit an expedition on evolution*). The phrase *acceptance of evolutionary theory*, in contrast, has been used for teachers' and students' perception of its scientific validity, its ability to explain phenomena, and its acceptance within the scientific community (Rutledge & Warden, 1990). The acceptance construct has been widely used in previous studies (see "Evaluating approaches aiming at attitude and belief change in the field of evolution and creation"). However, its validity has received severe criticism (Konnemann et al. 2012a; Smith 2010; Wagler and Wagler 2013). Nevertheless, we use the acceptance construct in addition to the attitude construct in the present paper to compare the findings from this study to prior findings.

In this study, we explored five key attitudinal outcome constructs. In addition to *acceptance of evolution*, we investigated *attitudes toward evolutionary theory* and *attitudes toward the Biblical accounts of creation* defined as summary evaluations of the respective attitude object. Referring to two separate attitude objects, these two attitudes can be combined in diverse ways. For instance, *pro*-evolution *pro*-creation positions can be distinguished from *pro*-evolution *anti*-creation, or *anti*-evolution *pro*-creation positions, the last combination being proper to creationist positions. Since not all creationist movements explicitly refer to the Bible within their specific beliefs, the third outcome construct of this study is *creationist beliefs* operationalized as either Young Earth beliefs (i.e., a rejection of evolutionary theory because of a literal reading of the Biblical accounts of creation; Astley and Francis 2010) or Intelligent Design beliefs (e.g., the belief that the complexity of the natural world provides strong evidence for the existence of an intelligent designer or the belief that a directed process—rather than variation and natural selection—accounts for evolutionary change; Reiss 2008). The fourth construct, *scientistic beliefs*, allows for differentiation between positions at the other end of the spectrum. In this study, scientistic beliefs are defined according to Stenmark (2013) as the view that there are no limits to science and that there is no area of human life to which science cannot successfully be applied. Moreover, adherents of scientism typically question the importance and relevance of disciplines outside the natural sciences (e.g., the humanities). The fifth construct investigated, *perceptions of conflict between science and theology*, accounts for the

fact that many young people perceive a conflict between science and religion (Billingsley et al. 2016; Höger 2008; Rothgangel 1999; Weiß 2016). Thus, the present study focuses on one of several existing views on the relationship between science and religion (e.g., conflict, independence, dialogue, integration; cf. "Epistemic insight").

These attitudinal constructs have been previously used to describe high school student attitudes in the field of evolution and creation (Konnemann et al. 2016). Characterizing student positions by means of multidimensional attitude profiles, the study described positions at both ends of the spectrum. Among the former, a scientistic *pro*-evolution profile was characterized by the most positive attitude toward evolutionary theory, the most negative attitude toward the Biblical accounts of creation, the lowest degree of creationist beliefs, and the highest degree of scientistic beliefs. A creationist *anti*-evolution profile, in contrast, was characterized by the most negative attitudes toward evolutionary theory, the most positive attitudes toward the Biblical accounts of creation, the highest degree of creationist beliefs, and the lowest degree of scientistic beliefs. In addition to those extreme profiles, there were non-extreme positions, for example, positions combining positive attitudes toward evolutionary theory and toward the Biblical accounts of creation to a balanced position (balanced *pro*-evolution) or positions privileging evolutionary theory above the Biblical accounts of creation without endorsement of scientism (non-scientistic *pro*-evolution). Furthermore, the least extreme profiles were associated with the lowest perception of conflict between science and theology as well as the most differentiated understanding of both the nature of science and the nature of theology, indicating some roles of epistemic insight with respect to more harmonious positions. In summary, this prior study provides evidence that epistemic insight might be associated with non-extreme positions.

Evaluating Approaches Aiming at Attitude and Belief Change in the Field of Evolution and Creation

Findings from prior research show that attitudes, generally, may be fairly stable (Ajzen 2001) and that acceptance of evolutionary theory, in particular, remains unaffected by factual information only. Table 1 presents a summary of previous studies investigating changes in acceptance of evolution.[2] The studies are classified according to the teaching approach used. They fall into the two broad categories *evolution-only*, i.e., approaches focusing on the teaching of evolution only, and *evolution + epistemic insight*, i.e., approaches integrating one or more features of epistemic insight into the teaching of evolution.[3] When we compared the effects by teaching approach, it became immediately apparent that studies classified as *evolution-only* approaches are largely ineffective with respect to acceptance of evolutionary theory (Bishop and Anderson 1990; Cavallo and McCall 2008; Demastes et al. 1995; Lawson and Worsnop 1992; Romine et al. 2017). In contrast, teaching approaches effect changes in acceptance if they combine evolutionary knowledge with features of epistemic insight. Among

[2] As there is no explicit research tradition on attitudes toward evolutionary theory, we report studies on acceptance of evolution which is a closely related construct. In contrast to our conceptualization of attitude, the construct "acceptance of evolution" is typically more rational and cognitive in nature (Konnemann et al. 2012a).

[3] The studies classified as "evolution + epistemic insight" generally do not contain an explicit reference to the concept of epistemic insight but were classified into this category according to the learning opportunities described in the respective papers, including, for example, activities on NOS or on different ways of relating evolution and creation.

them, there are studies that use epistemic insight into the nature of science (Athanasiou et al. 2012), as well as epistemic insight into ways of relating science and religion (Wiles and Alters 2011), or a discussion of different positions or different myths about the origin of life (Ingram and Nelson 2006; Matthews 2001; Verhey 2005). Reporting effects on specific positions, two of the studies including learning opportunities for epistemic insight observed special effects on both undecided and creationist students (Ingram and Nelson 2006; Verhey 2005; Wiles and Alters 2011).

Beyond these overall effects on acceptance of evolution, the empirical evidence for change in other attitude and belief constructs in the field of evolution and creation is less conclusive. Within religious education, there are several studies investigating students' attitudes toward the Biblical accounts of creation and students' understanding of creation (Fetz et al. 2001; Höger 2008; Höger 2016; Konnemann et al. 2013; Weiß 2016; Worsley 2013; Reich 2004). However, none of these studies have investigated teaching effects in (quasi-)experimental settings. The same holds true for creationist beliefs, where several studies have documented creationist beliefs among high school students (Astley and Francis 2010; Konnemann et al. 2012b; Francis and Greer 1999, 2001; Fulljames and Francis 1988), but an investigation of teaching effects is still missing. Concerning scientistic beliefs, a recent pre–post-study provides evidence that an explicit teaching of the methodological aspects of physics—in particular, discussing the power and limitation of science—had an impact on high school students' scientistic beliefs (Korte et al. 2017b). Lastly, two recent pre–post-evaluation studies of either a 2-week evolution module or a short 6-min intervention indicate that an explicit discussion of the relationship between evolution and religion as well as relevant epistemic underpinnings helps reduce students' perception of conflict (Barnes et al. 2017; Truong et al. 2018).

In summary, there is empirical evidence that epistemic insight might be associated with changes in acceptance, attitudes, and beliefs in the field of evolution and creation. It should be mentioned, however, that many of the reported studies used simple designs, for example, designs without control groups or using post-test data only. Furthermore, most existing studies investigate US American samples and have focused on acceptance of evolution only.

Positionality, Ethics, and Rationale of the Present Study

This interdisciplinary study involving researchers from both religious education and science education is based on the fundamental premise that a basic understanding of different disciplines (e.g., their bodies of knowledge and their ways of producing knowledge) and of how they interact is an important educational aim. Namely, human beings—in their quest for knowledge—approach the world in different ways depending on which aspect of reality they intend to investigate. Scientists, for example, focus on empirically accessible aspects of the world (Reiss 2009). Theologians, in contrast, study God and the relationship among God, human beings, and nature (Hunze 2002). Thus, a chief characteristic of literacy, on the most general level, is to understand differences among academic disciplines and their methods (Baumert 2002). In other words, developing student epistemic insight (cf. "Epistemic insight") is regarded a general educational aim.

Furthermore, this study is inspired by a strong appreciation of the diversity of positions resulting in a clear rejection of all kinds of indoctrination. Reducing the diversity of positions in the field of evolution and creation and fostering one specific position is decisively not the aim of the present study. Rather, this study is motivated by a modern understanding of diversity aiming at openness, responsiveness, and responsibility (Mansour and Wegerif

Table 1 Review of the research with respect to changes in acceptance of evolutionary theory

Study	Sample	Design	Teaching approach		Effect on acceptance
			Classification[a]	Description	
Abraham et al. (2012)	College, non-major biology students, USA, $n = 110$	Pre–post-design	Evolution-only	Introductory biology course: evolution and natural selection; "relatively simple and straight forward explanations of the Neodarwinian synthesis" (p. 416)	No
Athanasiou et al. (2012)	High school, 9th grade, USA, $n = 81$	Pre–post-design	Evolution-only	General biology class with focus on general science, cellular biology, genetics, ecology and evolution	No
Bishop and Anderson (1990)	College, non-major biology students, USA, $n = 192$	Pre–post-design	Evolution-only	s. Bishop and Anderson (1990)	No
Carter and Wiles (2014)	High school, 10th–12th grade, USA, $n = 107$	Pre–post-design	Evolution-only	General biology course, three-week evolution unit: learning cycles on variation, fossil evidence, natural selection (p. 148ff.)	No
Cavallo and McCall (2008)	Undergraduate biology students, USA, $n = 622$	Pre–post-design	Evolution + epistemic insight	"Evolutionary evidence lessons": some of the evidence for modern evolutionary theory with emphasis on the predictive nature of scientific theories	Yes
Cofré et al. (2017b)	University students from Early childhood education program, Greece, $n = 320$	Pre–post-design	Evolution + epistemic insight	Introductory biology course: general chapter on evolution, introduction to NOS, history of life, genetics, classification (p. 235)	Yes
Demastes et al. (1995)	Introductory biology students, USA, $n = 620$	Pre–post-design	Evolution + epistemic insight	NOS (precise information on teaching is missing)	Yes
Ingram and Nelson (2006)	High school students, Chile, EG n = 19, CG $n = 20$	Pre–post-EG–CG design with random assignment to groups	EG: evolution + epistemic insight CG: evolution-only	EG: evolution unit on natural selection with additional explicit NOS instruction CG: evolution unit on natural selection without NOS instruction	EG: Yes CG: No
Lawson and Worsnop (1992)	University students from biology, medicine or health-care education programs, USA, $n = 255$	Pre–post-design	Evolution + epistemic insight	Evolution course: history of life, evidences, diversity, inheritance, variation, speciation, macroevolution, NOS, different religious and scientific conceptions of the evolution/creation controversy (p. 11)	Yes

Table 1 (continued)

Study	Sample	Design	Teaching approach		Effect on acceptance
			Classification[a]	Description	
Matthews (2001)	College students, USA, $n = 37$	Pre–post-design	Evolution + epistemic insight	General biology course: Discussion and writing activities reflecting on several different creation myths, history of life, fossils, theories of evolution including creationism, Lamarckism, and natural selection, speciation, evolution of humans (p. 405)	Yes
Nadelson and Sinatra (2010)	University teacher education students, USA, $n = 89$	Pre–post-EG–CG with random assignment to groups	Evolution + epistemic insight	Both groups: Web-based tutorial from the understanding evolution website debunking common misconceptions of evolutionary theory and on the nature of science concepts in the context of evolution	Yes (both groups)
Verhey (2005)	University students, USA, $n = 103$	Post-test design with EG and CG	EG: evolution + epistemic insight CG: evolution-only	Introductory major biology course based on Campbell and Reece 2002: EG: comparative pedagogy including a discussion of scientistic and creationist positions, focus on NOS CG: evolution-only (p. 998ff.)	EG: yes CG: no
Wiles and Alters (2011)	High-school-level summer program, USA, $n = 81$	Pre–post-design	Evolution + epistemic insight	Course on evolutionary science: NOS, history of evolutionary theory, methods used in evolutionary biology, evidence, mechanisms, origin of species, applications. Extracurricular seminars and guest speakers: compatibility of evolution and religious faith, evolution/creationism continuum, evolution and racism (p. 2569ff.)	Yes

EG experimental group, *CG* control group

[a] Teaching approaches are classified into the categories "evolution-only," i.e., approaches that focus only on the teaching of evolution, and "evolution + epistemic insight," i.e., approaches integrating one or more features of epistemic insight into the teaching of evolution

2013). However, openness must not be misunderstood as arbitrariness. Whenever the epistemic foundations of one of the disciplines involved are challenged, responsiveness and responsibility must involve a resolute clarification of underlying epistemic misconceptions. For instance, creationist beliefs typically challenge modern theological readings of the Bible, taking the first chapters of Genesis literally. Scientistic beliefs, in turn, often challenge the epistemic foundations of science, neglecting its limitation to empirically acceptable aspects of the world. In conclusion, learning opportunities developing epistemic insight might play a key role in a simultaneous consideration of openness, responsiveness, and responsibility with respect to diversity of positions in the field of evolution and creation.

Research Question (and Hypothesis)

The main aim of this study was to explore how far student teachers' attitudes and beliefs change by attending a cross-curricular university course on evolution and creation bridging biological as well as Christian theological perspectives. More precisely, the main research question was as follows:

To what extent do student teachers' (1) attitudes toward evolutionary theory, (2) attitudes toward the Biblical accounts of creation, (3) creationist beliefs, (4) scientistic beliefs, and (5) their perception of conflict between science and theology change in response to a cross-curricular university course on evolution and creation providing learning opportunities for epistemic insight (with respect to the nature of science, the relationship between science and theology, and the relationship between evolution and creation)?

To align the study with previous research, we additionally used the MATE instrument (Measure of Acceptance of the Theory of Evolution; Rutledge and Warden 1999) to investigate students' acceptance of evolutionary theory. Moreover, pursuing a more exploratory research approach, we examined the extent to which changes in attitude profiles—in particular, changes from extreme to non-extreme attitude profiles—can be observed in association with the course work.

From previous research, we hypothesized that the inclusion of learning opportunities intended to develop epistemic insight might be associated with an increase in acceptance of evolution (see Table 1), a reduction in creationist and scientistic beliefs (Ingram and Nelson 2006; Korte et al. 2017b), and a reduction in conflict beliefs (Barnes et al. 2017; Truong et al. 2018).

Methods

Contextual Background and Description of Course Work

The cross-curricular course entitled "Students' conceptions on Evolution and Creation—theoretical foundations and empirical findings" was an elective course within a teacher education program for primary and secondary school teachers at the University of Education at Freiburg, Germany. The course took place during the 2016 summer term and was developed and taught by a biologist (Werner Riess) and a Roman Catholic theologian (Christian Hoeger). In 14 lessons of 90 min each, the following content was selected for course work: Evolution (classic and modern theories, evidence and basic insights into the epistemology of science

related to evolution, evolution of humans); Biblical accounts of creation (Genesis 1, 1–2, 4a, Genesis 2, 4b-3, Book of Job 38, Proverbs 8, 22–31) and theological interpretations (non-literal ways of reading the Biblical narratives, in particular historical-critical methods not conflicting with science and the idea of 'creatio continua'); Barbour's (1990) four models of the relationship of science and religion; Young Earth and Intelligent Design creationism in critical perspectives from the biological and theological points of view; role-play activity with a hypothetical debate around conflicting positions on evolution and creation; children's and adolescents' attitudes and conceptions concerning evolution and creation; and discussion of selected teaching approaches and methods for biology and religious education in primary and secondary school. In summary, the cross-curricular course contained several explicit learning opportunities intended to develop epistemic insight among student teachers (i.e., activities providing knowledge about the nature of science as well as about the nature of theology, knowledge about ways of relating science and religion in general, and knowledge about evolution and creation in particular).

Design and Procedures

A pre–test–post-test, two-group, quasi-experimental design was used in this study. Pretest–post-test data were collected at the beginning and at the end of the term. The treatment group took part in the elective cross-curricular course work while the students in the control group attended other elective courses as part of their studies (e.g., courses on mathematics, French, music, pedagogy). Both groups participated in the pretest and post-test. All participants received a financial refund after participation in both tests.

Sample

There were 49 participants in the final sample for this study, 26 in the treatment, and 23 in the control condition. Sample characteristics are given in Table 2. On average, study participants were between 23 and 24 years old. The majority of participants were female (81.6%) and studied biology (84.4%). Approximately one fourth of the students studied theology (27.1%). Concerning the teacher education program, 65.3% followed a program for teaching in primary

Table 2 Sample characteristics

Sample characteristics		All ($n = 49$)	TG ($n = 26$)	CG ($n = 23$)
Age [years; M (SD)]		23.35 (4.15)	23.42 (4.97)	23.26 (3.06)
Sex [%]	Male	18.4	15.4	21.7
	Female	81.6	84.6	78.3
Study subject [%]	Biology	84.4	100.0	69.6
	Christian theology	27.1	12.0	43.5
Religious denomination [%]	Catholic	58.3	53.8	63.6
	Protestant[a]	22.9	23.1	22.7
	Protestant Free Church	8.3	11.5	4.5
	Muslim	2.1	3.8	0.0
	Unaffiliated	8.3	7.7	9.1

TG treatment group, *CG* control group

[a] In this study, the term Protestant is used for students affiliated to the Protestant Church in Germany (Lutheran, Reformed, and United)

schools, and 34.7% for teaching in secondary schools. In terms of religious affiliation, just over half of the students were Catholic (58.3%), more than one fifth were members of the Protestant Church in Germany (i.e., Lutheran, Reformed, United; 28.6%), 8.3% were affiliated to Protestant Free Churches, 2.1% were Muslim, and 8.3% were unaffiliated. These percentages indicate an above-average frequency of Catholic students and a low number of unaffiliated students in our sample compared with the total population of Germany (36.2% unaffiliated, 28.5% Catholic, 26.5% Protestant, 4.8% Muslim, 3.9% others; fowid 2016) and compared with the region of Baden-Wuerttemberg (37% Catholic, 33% Protestant, 24% unaffiliated and others, 6% Muslim; statistika 2011).

Measures

The measures used in this study were adapted from an attitude survey developed by Konnemann et al. (2016). The survey contained separate closed-ended Likert-type scales for the five dependent variables (1) attitude toward evolutionary theory (20 items), (2) attitude toward the Biblical accounts of creation (17 items), (3) creationist beliefs (14 items), (4) scientistic beliefs (10 items), and (5) beliefs about a conflict between science and theology (9 items). Ratings were given on a 4-point response scale ranging from "disagree strongly" to "strongly agree" with high values indicating high agreement. For further information on the scales, including validity considerations, see Konnemann et al. (2016). In addition, the Measure of Acceptance of the Theory of Evolution instrument (MATE, 20 items; Rutledge and Warden 1999) was used to allow comparison with previous studies (5-point Likert). The main difference between the measures on acceptance and attitude is that—according to the different theoretical underpinnings (see "Attitudes and beliefs concerning evolution and creation")—the attitude measures focus on personal cognitive and affective evaluations of evolutionary theory while the acceptance measure concentrates on the perceptions of evolutionary theory's scientific validity. See Table 3 for sample items and scale characteristics. For all measures, groups and times of measurement, Cronbach's alpha reliability was $\alpha > 0.70$.

Data Analysis

To answer the main research question, one-way repeated measures ANOVAs were conducted to compare the effect of treatment and control condition on the different attitude and belief constructs before (pretest) and after (post-test) the treatment using group as the factor. Beforehand, we checked whether the prerequisites for using an ANOVA (normal distribution and variance homogeneity) are fulfilled. These conditions were met in the present case. For in-depth analysis of changes, we categorized all students into the attitude profiles described by Konnemann et al. (2016). Contrary to that study, categorization of students did not involve a separate Rasch analysis due to the limited sample size, but students were manually assigned to the different profile categories using mean values. Subsequently, profile changes were analyzed via cross tabulation.

Results

Descriptive results for the dependent variables are shown in Table 3. Concerning pretest values, attitudes toward evolutionary theory were positive in both groups, while attitudes

Table 3 Scale characteristics, sample items, mean scores, and standard deviations

Scale	Sample item	No. of items	Group	Cronbach's α		Mean (SD)	
				Pre	Post	Pre	Post
Attitude toward evolutionary theory	My attitude toward evolutionary theory is definitely positive.	20	TG	0.97	0.89	3.42 (0.58)	3.66 (0.29)
			CG	0.81	0.71	3.63 (0.26)	3.64 (0.21)
Attitude toward the Biblical accounts of creation	The Biblical accounts of creation deepen my life.	17	TG	0.97	0.93	2.53 (0.80)	2.47 (0.70)
			CG	0.95	0.97	2.81 (0.72)	2.78 (0.84)
Creationist beliefs	I believe that God made the world in six days of 24 hours.	14	TG	0.93	0.87	1.77 (0.72)	1.42 (0.39)
			CG	0.78	0.87	1.64 (0.50)	1.57 (0.46)
Scientistic beliefs	Human knowledge is limited to what can be discovered by scientific methods.	10	TG	0.96	0.85	1.79 (0.44)	1.81 (0.48)
			CG	0.89	0.87	1.63 (0.52)	1.56 (0.46)
Perception of conflict between science and theology	For me personally, there is a conflict between science and theology.	8	TG	0.83	0.88	2.01 (0.70)	1.61 (0.52)
			CG	0.86	0.87	1.60 (0.47)	1.62 (0.57)
Measure of acceptance of the theory of evolution (MATE)	Evolutionary theory is supported by factual, historical, and laboratory data.	20	TG	0.96	0.91	4.06 (0.76)	4.47 (0.40)
			CG	0.83	0.83	4.35 (0.37)	4.51 (0.32)

M mean, *SD* standard deviation, *TG* treatment group, *CG* control group; 4-point Likert-type scales ranging from 1 to 4; higher scores indicate a more positive attitude or a higher agreement with the respective belief

toward the Biblical accounts of creation were neutral in the treatment group and slightly positive in the control group. According to mean values, both creationist and scientistic beliefs were rejected in both groups. Furthermore, students—on average—perceived no conflict between science and theology. Acceptance of evolution was described by a high level of acceptance (according to a classification of acceptance scores by Rutledge and Sadler [2007]). Concerning differences in pretest values, there were significant differences between the treatment group and the control group (independent samples *t* test) for the variables perception of conflict ($t[47] = 2.38$, $p < .05$) and acceptance of evolution ($t[47] = -2.19$, $p < .05$). More precisely, students' perception of conflict was higher and acceptance of evolution was lower in the treatment group than in the control group. A comparison of pretest–post-test values shows that substantial changes occurred only within the treatment group for creationist beliefs ($F[1,47] = 5.10$, $p < .05$), perceptions of conflict ($F[1,47] = 9.74$, $p < .01$), and acceptance of evolution (MATE; $F[1, 47] = 7.96$, $p < .01$).

To answer the main research question concerning the effects of epistemic insight on the attitude and belief constructs, we conducted a repeated measures ANOVA comparison of pretest scores and post-test scores using group as the factor. The results confirm the finding that there was no effect on attitudes toward evolutionary theory and on attitudes toward the Biblical accounts of Creation, neither for time nor for the interaction of time and group. Concerning creationist belief, the results revealed a main effect of time ($F[1,47] = 11.44$, $p < .01$, $\eta^2 = 0.20$) and a significant interaction between time and group ($F[1,47] = 5.10$, $p < .05$, $\eta^2 = 0.10$), indicating that there was a relatively large decrease in all participants' agreement with creationist beliefs, and the decrease was larger in the treatment group than in the control group (medium effect; classification of effects according to Cohen 1988). By analogy, there was a main effect of time ($F[1,47] = 7.83$, $p < .01$, $\eta^2 = 0.14$) and a significant

interaction of time and group ($F[1,47] = 9.74$, $p < .01$, $\eta^2 = 0.17$) for students' perception of conflict, indicating that there was a general decrease in conflict beliefs over time as well as a differential change in conflict beliefs between the treatment group and the control group (large effect). In contrast, the repeated measures ANOVA on scientistic beliefs revealed no significant pretest–post-test changes for either study group. Lastly, the rmANOVA on acceptance of evolution as measured by the MATE revealed a main effect of time ($F[1,47] = 13.48$, $p < .01$, $\eta^2 = 0.22$) and a significant interaction of time and group ($F[1,47] = 7.96$, $p < .01$, $\eta^2 = 0.15$), indicating an overall increase in acceptance for all participants (large effect) regardless of the group, as well as a stronger increase in the treatment group than in the control group (large effect).

Because of the small sample size, it was impossible to statistically analyze changes in attitude profiles. Nonetheless, some descriptive findings provide case-based evidence for effects associated with the impact of epistemic insight on attitude profiles. Comparing pretest–post-test profiles, the main result is that in the treatment group, all students who had been classified into one of the extreme profiles in the pretest changed to less extreme positions in the post-test. More precisely, cross-tabulation analysis revealed that the three students classified as scientistic *pro*-evolution in the pretest (11.5%) changed either to a distinctly non-scientistic *pro*-evolution profile ($n = 1$)—characterized by a mean rejection of scientistic beliefs—or to a borderline scientistic *pro*-evolution profile ($n = 2$)—characterized by a neutral position toward scientistic beliefs. In addition, the two students in the treatment group classified as creationist *anti*-evolution in the pretest (7.7%) changed to balanced *pro*-evolution positions in the post-test—characterized by positive attitudes toward both evolutionary theory and the Biblical accounts of creation and combined with a rejection of both creationist and scientistic beliefs. In contrast, there is no evidence for changes in extreme positions in the control group. In summary, there is initial evidence for change with respect to student positions when considering students holding extreme attitude profiles.

Discussion

The main aim of this evaluation study was to explore changes in attitudes and beliefs associated with epistemic insight in the field of evolution and creation. To achieve this aim, multiple measures focusing on attitudes, beliefs, and acceptance were applied. From previous research, we expected changes particularly in the acceptance measure (MATE) and in the beliefs measures. Furthermore, we expected epistemic insight to effect changes particularly with respect to extreme beliefs in the field (i.e., creationist and scientistic beliefs). The main results of the evaluation of the cross-curricular course on evolution and creation, including learning opportunities intended to develop student teachers' epistemic insight, are that attitudes remained stable while beliefs and acceptance changed. Specifically, whereas attitudes toward evolutionary theory and toward the Biblical accounts of creation remained unchanged, we found changes in acceptance of evolution, creationist beliefs, and perceptions of conflict between science and theology in the treatment group but not in the control group. In contrast, there was no overall change in scientistic beliefs. However, when analyzed individually, there was initial evidence for belief change within the small group of students with scientistic *pro*-evolution positions in the treatment condition. In conclusion, there was evidence of change, especially for students holding beliefs at one or the other end of the spectrum.

What might be the reasons for effects on acceptance of evolutionary theory but an absence of effects on attitudes? There are three possible explanations. The first is attitude stability. Psychological attitude research has shown that political and religious attitudes are often resistant to change due to their strength, among other reasons (Bohner and Wänke 2002). Indeed, several studies have linked people's positions in the field of evolution and creation to their political and religious backgrounds (Mazur 2005, 2010). In contrast, the changes in acceptance of evolutionary theory described in this paper are congruent with prior studies reporting on changes in acceptance associated with epistemic insight (see Table 1). In this particular study, explicit teaching about ways of relating science and religion as well as their epistemic underpinnings and a discussion of different positions has putatively contributed to the observed changes in acceptance. The second explanation relates to differences in the theoretical underpinnings for acceptance and attitudes. Acceptance of evolution, as described above (see "Attitudes and beliefs concerning evolution and creation"), includes perceptions of the scientific validity of evolutionary theory (Rutledge and Warden 1999). Consistent with this definition, the acceptance measure explicitly addresses epistemic aspects (e.g., The theory of evolution is incapable of being scientifically tested [item 2]; Evolution is a scientifically valid theory [item 20]). In contrast, the attitude measures used in this study operationalize attitude more broadly as a personal tendency toward the respective attitude object, which is expressed by cognitive and affective evaluations (e.g., *important*, *interesting*). Hence, there is a greater conceptual overlap between epistemic insight and acceptance than between epistemic insight and attitude. A third explanation relates to the possibility that effects of epistemic insight on attitudes only manifest themselves for persons holding particular attitude combinations. It might be argued, for example, that epistemic insight into the relationship between science and religion should induce attitude change in a person who feels forced to choose between evolution and creation and who—as a consequence—holds a negative attitude toward either evolution or creation. In this particular study, however, only a few students held such views. In contrast, attitudes—both toward evolutionary theory and toward the Biblical accounts of creation—were comparably positive in the present student teacher sample when compared to high school students (Konnemann et al. 2016). It might be assumed that a study using a sample with less positive attitudes and a higher proportion of extreme attitude profiles might have been able to report on attitude changes.

What might be the reasons for effects on creationist beliefs and conflict beliefs, but an absence of an overall effect on scientistic beliefs? The most likely explanation is that creationist beliefs as well as conflict beliefs were explicitly addressed in the course work, while there was no explicit teaching addressing scientistic beliefs. In contrast, a recent study directly addressing scientistic beliefs and including an explicit discussion of the power and limitations of science documented changes in high school students' scientistic beliefs (Korte et al. 2017b). Hence, it can be assumed that explicit teaching about the limitations of science would have produced an overall change in scientistic beliefs and not only individual changes. Another likely explanation for the absence of an overall effect on scientistic beliefs is that these were relatively rare in the present sample. Compared to a larger sample of German high school students (Konnemann et al., 2016), the present student teacher sample was characterized by a considerably lower degree of scientistic beliefs (M[SD] = 1.72[0.63][4] vs. M[SD] = 2.25[0.57]) and a considerably lower proportion of students holding a scientistic *pro*-evolution profile (8.0% vs. 21.8%). In contrast, both the overall degree of creationist beliefs (M[SD] =

[4] Means and standard deviations refer to the whole sample of n = 49 student teachers.

1.70[0.62][4] vs. *M*[SD] = 1.66[0.61]) and the proportion of creationist *anti*-evolution profiles were similar to the high school student sample (4.1% vs. 4.0%, respectively). Taken together, course work and sample features might have influenced the results and impeded overall effects on scientistic beliefs.

What are the strengths and limitations of the present study? The present study applies an exclusively quantitative research design. Being the first evaluation study in the field taking a wider view and not focusing on acceptance or rejection of evolution only, one might question whether qualitative approach using interview or focus group data, or a mixed methods design collecting quantitative and qualitative data simultaneously, would have obtained better results. There were three main reasons for taking the present approach: First, it directly takes up existing instruments that not only have been field-tested and validated but also have proven useful for describing diversity in the field (Konnemann et al. 2016). Second, the quantitative approach allows statistical evaluation of the effects and comparison of effects to existing—predominantly quantitative—studies (see Table 1). Third, the present study was designed as an initial study that—in case of success—might be extended to a sequence of studies following a sequential mixed methods approach (Teddlie and Tashakkori 2006). The pursued research strategy was to first explore possible applications of the existing instruments in an instructional setting and to add a qualitative investigation of the reasons for possibly detected changes in a second step. A third step might be an investigation of profile changes in a sample sufficiently large for applying Rasch methodology and for statistically analyzing profile changes.

Conclusions and Perspectives

What kind of training should student teachers receive to be adequately prepared for questions on topics that bridge science and religion? The present study lends credence to the hypothesis that an integration of epistemic insight into student teachers' coursework might reduce extreme positions. Specifically, the present study documents changes in beliefs and acceptance associated with a teaching approach reflecting epistemic insight within the multidisciplinary arena of evolution and creation. Notably, changes only occurred for those beliefs that were directly addressed in the course work. This insight is highly relevant for teacher training programs both when considering how to structure the teacher training and what teaching strategies to provide. Addressing beliefs through a deliberate inclusion of learning opportunities fostering specific aspects of epistemic insight—for instance, addressing conflict beliefs through a discussion of different ways of relating science and religion—appears a reasonable teaching strategy in line with the results of the present study. Similarly, Khishfe and Abd-El-Khalick (2002) concluded that developing informed conceptions of NOS requires an explicit and reflective instructional approach.

Further research in this area is necessary to further explore the effects of epistemic insight on attitudes and beliefs in the multidisciplinary field of evolution and creation. In this particular evaluation study, we were not able to fully understand all effects. As discussed above, it is likely that sample characteristics hindered overall effects. Follow-up intervention studies should take care to provide better baseline conditions (for example, using a sample with a higher proportion of extreme positions). Furthermore, we were only able to report case-based evidence for changes in students holding extreme attitude profiles due to the small sample size. Similar studies using larger samples would allow an in-depth analysis of individual changes based on attitude profiles. To validate the results of the present study and

to better understand changes in positions, both supplementary interviews investigating the role of epistemic insight in attitude and belief change, and quantitative studies using larger samples would be certainly desirable. Finally, because of the design of the study, it is not possible to attribute the reported effects directly to particular course content. Using an experimental pretest–post-test design and more systematically varying features of epistemic insight is a direct desideratum of research.

Lastly, it appears especially important that attempts building on this study also try to account for scientism and include epistemic reflections of the power, relevance, and limitations of science within a wider framework. In the course work of the present study, scientistic beliefs were not explicitly addressed and only case-based evidence for belief change emerged. In contrast, two recent studies in physics education indicate that an explicit discussion of science's power and relevance increases scientistic beliefs while a discussion of its limitations helps to reduce scientistic beliefs in high school student settings (Korte et al. 2017b; Korte et al. 2017a). Hence, the ability to see the power, relevance, and limitations of science within a wider framework is probably an important feature of epistemic insight (Billingsley and Hardman 2017), which has only received limited attention so far.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

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