

## Culture and personal epistemology: U.S. and Middle Eastern students' beliefs about scientific knowledge and knowing

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**Abstract.** Middle Eastern (Omani) and Western (U.S.) students' beliefs about knowledge and knowing in the sciences were compared on four dimensions of personal epistemology proposed by Hofer and Pintrich (*Review of Educational Research* (1997), 67, 88–140). As predicted, given their experiences with comparatively traditional political and religious institutions, Omani more so than U.S. college students were more likely to accept scientific authorities as the basis of scientific truth. Furthermore, Omani men were more accepting of authorities than were Omani women, but there was no gender difference among U.S. students. Omani more than U.S. students also believed that knowledge in the sciences was simpler and more certain, which is consistent with comparisons between U.S. and Asian students (e.g., Qian & Pan, 2002, A comparison of epistemological beliefs and learning from science text between American and Chinese high school students. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 365–385), Mahwah, NJ: Erlbaum). Students in the two countries did not differ, however, in whether their beliefs were based on personal opinions versus systematic evidence. Suggestions for further research included directly assessing experiences with, and attitudes toward, authorities in academic and other areas of students' lives.

### 1. Introduction

Whether and in what ways culture influences personal epistemology – individuals' beliefs about the nature of knowledge and knowing – is part of the broader effort to understand associations between culture and cognition. Considerable progress toward that understanding comes from comparisons between Western and Asian cultures. Such comparisons are particularly compelling because of clearly distinguishable, long-standing philosophical and religious traditions (Nisbett, 2003). Likewise, cross-cultural studies of personal epistemology thus far have examined differences between Western and Asian cultures as well as comparisons within and between Western countries (Alexander & Douchy, 1995; Chan & Elliott, 2002; Jacobson, Jehng, & Maouri, 1997; McDevitt, Sheehan, Cooney, Smith,

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& Walker, 1994; Mason & Castiglioni, 2000; Qian & Pan, 2002; Youn, 2000). Research on culture and cognition has implications for many social, self, and educational processes (e.g., Feather, 1993; Nisbett, 2003; Volet & Järvelä, 2001), including the role of authority (Feather & McKee, 1993; Raviv, Bar-Tal, & Raviv, 2003).

By contrast, there is little systematic evidence regarding the applicability of Western conceptualizations of personal epistemology to Middle Eastern Muslim cultures, or to comparisons between Western and Middle Eastern Muslim cultures.<sup>1</sup> Studies of Middle Eastern populations, for example, are noticeably absent from the extensive literature on individualism–collectivism (e.g., Triandis, 1995). In addition to the importance of Middle Eastern societies, both historically and in view of contemporary political and social events as well as their comprising a sizable proportion of the world's population, features of Middle Eastern societies are eminently suitable for examining relations between culture and cognition in general, and culture and epistemic beliefs in particular.

In the case of Middle Eastern societies, although there is considerable variation among countries in the region, a prominent feature consists of relatively authoritarian political-religious vertically collective cultures (Triandis, 1995) in which the political and social discourse involves status and power differences. At issue is whether such cultural characteristics, which involve how society members relate to one another, translate into beliefs about knowledge and knowing. The connection between general culture-based interpersonal relations and learning is predicted by Schommer-Aikins's (2004) embedded systemic model of epistemic beliefs. According to this model, one's cultural relational views have important implications for learning (especially classroom learning) to the extent they reinforce asymmetrical hierarchical relationships with experts. Given culturally based experiences with asymmetry, learners are more likely to accept omniscient authority-based claims, a predominant feature of less sophisticated epistemological beliefs (Baxter-Magolda, 1992, 2004; Belenky, Clinchy, Goldberger, & Tarule, 1986; Hofer, 2002; Hofer & Pintrich, 1997; Perry, 1970). Support for this view thus far is based on evidence obtained in Western societies. The present study examined whether cultural differences in authority relations would be reflected in epistemic beliefs.

Authority-related cultural characteristics may have influences that extend beyond acceptance of expert knowledge claims to involve the range of personal epistemic beliefs (also referred to as personal theories) proposed by Hofer and Pintrich (1997; Hofer, 2002, 2004). These core beliefs consist of four dimensions: (a) knowledge is simple versus complex, (b) knowledge is certain versus in a state of flux, (c) whether knowing is justified on the basis of dualistic, multiplistic opinions, or evaluative standards of evidence, as well as (d) the degree of reliance on authority to judge the veracity of knowledge claims. This dimensional approach (see also

Schommer-Aikins, 2002) recognizes that learners' beliefs are relatively independent and need not develop synchronously. For example, students in a beginning physics course may believe that knowledge is complex and interrelated (considered a relatively sophisticated epistemic belief) but also unchanging (considered a less mature belief). Further, the profile of epistemic beliefs may vary by knowledge domain – beliefs about physics versus history – or involve some combination of domain-specific and generalized epistemic beliefs (Hofer, 2000). Beliefs also depend on how specific or general is the reference domain, for example, knowledge in general, a scientific domain such as biology, or a specific area of research and theory (e.g., quantum mechanics).

The domain of knowledge is thus critical when examining cultural differences, and must minimize potential confounding effects of content differences. Comparing epistemic beliefs about world history in two cultures, for example, would confront likely differences in how that history was portrayed. Similar confounding would be least probable with formal disciplines such as mathematics or logic. However, such formal disciplines do not involve evidence-based claims, which are prominent epistemic concerns. Accordingly, science was selected as an appropriate referent for the present study primarily because there is relatively comparable content among widely varying educational systems, and it has been the domain of choice in previous research (Hofer, 2000; Hofer & Pintrich, 2002). The present study thus consisted of a cross-national comparison between college students' epistemic beliefs regarding science in one Middle Eastern Muslim country, the Sultanate of Oman, with those of U.S. college students, who exemplify the consequences of Western cultural influences. At issue here is whether, and in what manner, Omani and U.S. college students are similar or differ on the proposed four dimensions of epistemic beliefs that would be expected based on their cultural context. We begin by describing dominant features of Omani culture and their potential for shaping those beliefs, recognizing at the outset the considerable heterogeneity within that society that undoubtedly exists as well.<sup>2</sup>

Similar to other countries in the region, Omani society is highly structured, both politically and religiously. Politically, it is a long-standing monarchy; the Sultan is head of state, the highest and final authority, and the supreme commander of the armed forces. There have been some democratizing trends, however. Created by Royal Decree in 1997, the basic statute of the state established the Council of Oman. The Council is a bicameral legislature with the Majlis Shura (Consultative Council), whose members are elected by Omani citizens, and the Majlis Al Dawla (State Council), whose members are appointed by the Sultan. Islam, the state religion exerts profound influence over most aspects of Omani society in that the Quran prescribes politics, economics, law and justice, and social behavior, as well as theology. Most Omanis are Ibadhi, with a minority adhering to Sunni

or Shia Islam. The legal system is based on both English common law and Islamic law. As in other Muslim countries, relationships between secular and religious law and the courts are complex. Religious conflicts have not been prominent in Oman, however, which extends tolerance both to Muslims and non-Muslims. The ministry of Awqaf and religious affairs, which promotes the role of Islam in Omani society, provides the imams of the mosques with general guidelines that encourage unity among Muslims in Oman and other places.

As in other Moslem countries, tradition plays a significant role that affects women's social and economic destinies. Although from the very outset of his reign Sultan Qaboos resolved that Omani women should not be marginalized in the new modern Sultanate, and many laws and regulations were issued pursuant to that goal, women continue to face obstacles. Illiteracy among older women hampers their ability to participate in many sectors of the society. Data on the educational status of the adult Omani population also reveals that for those older than 15 years, Omani women are less highly educated than are Omani men. At the same time, however, overall educational levels have been rising with significant improvement in the educational status of women (Rassekh, 2004). Comparative enrollments of boys and girls also indicate progress in reducing the gender gap with only a slight difference in the net enrollment ratios. Thus, education is one area in which there is greater equity. Ninety percent of all girls who are eligible attend elementary school; they also represent half of the students attending public schools, approximately half of the students at Sultan Qaboos University, and they generally receive half of the government grants to study abroad. The government also encourages Omani women to contribute to the national economy as working women, and the Ministry of Social Development provides support for women's affairs to improve the quality of life for their families and to improve their contributions to the community.

Thus Oman is a relatively hierarchical Islamic country that has endeavored to keep pace with global development and to advance women's socio-economic roles while adhering to traditional religious norms, values, and cultural customs. Albeit with liberalizing segments within the society, embedded traditions and customs continue, and women still face certain obstacles in their social, political, and economic lives. This contrasts with the majority of Western cultures, such as the U.S., which is highly individualistic and anti-authoritarian (e.g., Jacobson et al., 1997; Triandis, 1995), including greater (although not total) gender equity. Given that gender is inextricably woven into the more traditional culture of Oman we would expect differences between men and woman on gender-related cultural variables. Such differences should, however, be less evident in more gender egalitarian Western cultures. The present study focused on whether and in what manner these cultural differences potentially transfer to students' personal epistemic beliefs.

The predominant features of Omani culture, politics, and religion thus appear to have considerable relevance for epistemic beliefs related to authority. Specifically, we would expect that Omani more so than U.S. students would trust and accede to authorities in many areas. As suggested by Schommer-Aikins's (2004) embedded systemic model, experiences with hierarchical interpersonal relations should translate to acceptance of authority claims in evidence-based knowledge domains such as science. Predictions are not as straightforward, however, regarding gender differences in Oman. One possibility is that because Omani men are more involved in the religious and political life of the country they may be more empowered and rely less on authorities as sources of knowledge than would Omani women who are subject to greater restrictions and dictates based on tradition. Just as plausibly, however, Omani males' greater exposure to cultural authorities could render them more, rather than less, susceptible to authority, whereas highly achieving and selected Omani college women who have transcended culturally based gender restrictions would be less reliant on authority. Whereas gender is important in Omani society, whether and how this translates to epistemic beliefs about knowledge and knowing in science in particular remains to be determined. By contrast, in the U.S., because of greater equity in many areas, including the sciences, gender differences with respect to authority should be less evident.

Although there have been no previous cross-national comparisons between the epistemic beliefs of Arab Muslim and U.S. students, Al-Salhi (2001) provides the most relevant source of information in his examination of Saudi college students matriculating in science and religious studies. Using an adapted version of Schommer's (1990) Epistemological Beliefs Questionnaire, translated into Arabic, Al-Salhi identified two dimensions (factors): active learning and simple/certain knowledge. Of the two, simple/certain knowledge was more easily interpretable. An examination of the constituent items, however, suggests that the second dimension is more aptly described as a combination of simple/certain knowledge and acceptance of authority. Al-Salhi found that male students of religion scored higher on the simple/certain (and authority) dimension than did female religion students, but male and female science students did not differ. Consistently, by a large margin, both for those in science and religion curricula, male more so than female students listed "trust in the source" when asked how they judged the truth of claims. To the extent Saudi students are comparable, these results suggests that Omani men more so than women may be more accepting of authority.

Implications of Middle Eastern culture for whether scientific knowledge is simple and certain, and the extent that justification is based on opinion or evaluated according to agreed-upon standards, is less clear given what is known at this point. Because of suggestions that Omani teachers place considerable emphasis on repetition and memorization (Rassekh, 2004),

however, we may expect Omani more so than U.S. students to believe more strongly that knowledge is simple and certain. This would be consistent with evidence from Asian samples, which suggests that U.S. students are less likely to hold such beliefs (Qian & Pan, 2002).

To summarize, Omani and U.S. college students responded to a survey designed to assess personal epistemic beliefs about knowledge (simple and certain) and knowing (justification and source) in science. As noted earlier, we focused on science because this domain of knowledge is likely to be equivalent and well defined in the two countries. Omani students responded to an Arabic translation of the survey in order to eliminate differences in familiarity with English. Although a necessary component of the study, dimensionality of the epistemological cognitions in the two cultures was not of central interest. Rather, we focused on the development of scales that to the extent possible were equivalent in meaning and psychometric properties. It should be noted that the present study involved both level and structural predictions (see van de Vijver & Leung, 1997). We predicted there would be level differences in the degree of acceptance of authority: higher in Oman than in the U.S. Structural differences were expected in that the relationships between authority and gender were predicted to vary across cultures, specifically that gender and authority would be related in Oman but not in the U.S.

## **2. Method**

### **2.1. SURVEY FORMAT**

Both the U.S. and Oman versions of the epistemology questionnaire were introduced as “concerned with how students view knowledge and knowing.” An informed consent statement reinforced that completion of the survey was voluntary and anonymous and stressed to students that neither their teachers nor anyone at their university would see their responses. The Oman version, completely in Arabic, assessed students’ epistemic beliefs and obtained demographic and education-related information: gender, year in college, major or intended major, grade point average and kind and number of high school and college science courses they had taken. In the U.S., the epistemology questionnaire was one component of a larger study (the second of five sections) that was introduced as concerned with students’ beliefs, attitudes and understanding of scientific information.

### **2.2. EPISTEMIC BELIEFS**

The epistemology survey itself consisted of 35 statements to which respondents indicated their level of agreement using a 5-point Likert scale response format (strongly disagree to strongly agree). As discussed

previously, we framed the survey to reflect students' beliefs about "science", and each statement included the term "science" or "scientific". There were four sets of statements. The "simplicity" scale consisted of eight statements that asked students whether knowledge consists of simple, discrete truths or facts versus related ideas, for example, "Scientific knowledge is mainly made up of discrete facts". Twelve statements assessed students' beliefs about whether scientific truth is certain and relatively stable or changing (the "certainty" scale), for example, "Most questions in science have only one right answer". Nine statements elicited students' beliefs about the scale to assess justification of knowledge. Three statements focused on whether knowledge is based on objective reality (e.g., "What is regarded as scientific truth is directly knowable"), three that scientific truth is more a matter of opinion than fact (e.g., "There is really no way to determine whether good answers to scientific problems have been discovered"), and three that referred to scientific truth as evaluated by agree-upon methods (e.g., "Scientific knowledge is based on whether researchers consistently arrive at the same conclusions"). Finally, six statements elicited students' acceptance of external authority (referred to as "source"), for example, "A person can just accept answers from the experts in this subject without question".

### 2.3. ARABIC TRANSLATION

To eliminate the effects of variation in Omani students' proficiency in English, the U.S.-developed instrument was translated into classical Arabic. Changes that were made would classify this as an adaptation in which there are changes in wording to make the statements more appropriate to the Omani culture (van de Vijver & Leung, 1997). A native speaker translated statements originally drafted in English into Arabic. In order to ensure accuracy of the translation, the items were then back translated by a second native speaker (the second author), and validated by additional native speakers from the university. Final adjustments to the Arabic version of the instrument conformed as closely as possible to both the conceptual equivalence of Arabic and English words and local linguistic conventions. In general, the translation posed few difficulties. Perhaps, the most important change was the substitution of the Arabic word meaning "expert" for the English "authority" because the latter would be interpreted in that culture to include political/social authorities as well as the intended scientific ones. Substituting "expert" is therefore more precise in conveying the intended meaning of the English term.

Additional alterations were:

- Use of the Arabic word that refers to "new information" instead of the English "more information"
- Substitution of the Arabic term "separate" for the English "discrete" as in "separate facts"

- Use of an Arabic term for “opinion” that refers to a conclusion that an individual comes to as opposed to a broadly held opinion
- Substitution of the Arabic term that refers to “the sciences” rather than “the areas of science”
- Use of the Arabic word that conveys the slightly greater imperative of “should” for the English “can” as in “A person can just accept answers ... ”.

## 2.4. PARTICIPANTS AND SAMPLING PROCEDURE

### 2.4.1. *Omani Students*

Omani participants were 231 students at Sultan Qaboos University (the country’s only public university) located in the Muscat Region of the Sultanate of Oman. The university has seven colleges (medicine and health sciences, engineering, agricultural and marine sciences, science, commerce and economics, education, and arts and social science) and a language center. Students sampled lived in university residence halls that housed students from families outside of the Muscat Region. Using an opportunity sampling procedure, surveys were distributed to students by residence hall supervisors. Of those who completed the surveys, slightly over half were males (55%), and in their first year (59%) at the university. Because of residence hall policies, after their first year, male students are subsidized to live off campus, but females remain in the dorms (a reflection of Omani culture). As a consequence, the dorm population consisted primarily of freshman males and upper class-level females. This was reflected in the sample, 53% of which consisted of male freshmen and 38% sophomore and above females. We examined the consequences of this difference and statistically controlled for possible confounding effects.

Table I presents the distribution of Omani (and U.S.) students according to their declared or intended major that in Oman also identified the college in which they were enrolled. Because of our focus on epistemology in science, we divided major fields according to their science content (high, medium, or low) to determine, and potentially control for, between country differences. After the first year of high school, students in Oman are separated into the science stream or the arts stream. All those in the science stream take courses in physics, chemistry, and biology. Given that the first four colleges listed in Table I only admit students from the science stream, we can assume they had considerably more science courses than did students in the remaining colleges. Some of the science stream students are eligible to enroll in humanities-based colleges; however, those from the arts stream in high school cannot enroll in the science-based colleges. We therefore designated students in the colleges of medicine, engineering, agriculture, and science as having a more extensive science background; those in commerce and economics to have a moderate amount



Table I. Distribution of students by Omani and U.S. students' declared or intended major

College	Oman (%)	U.S. (%)	Science <sup>a</sup>
Medicine	5	4	High
Engineering	10	14	High
Agriculture	9	0	High
Science	17	12	High
Commerce & Economics	14	28	Moderate
Education	8	12	Low
Arts & Social Sciences	36	28	Low
Language Center	1		
<i>n</i>	198 <sup>b</sup>	151 <sup>b</sup>	

<sup>a</sup>Relative experience with science; coding Low = 1, Moderate = 2, High = 3.

<sup>b</sup>Note: Number of students who indicated their major or intended major.

of experience; and those in education, and arts and social sciences with the least science background. It should also be noted that the science-based and the commerce and economics colleges require English proficiency. Students who need more English enroll simultaneously in the Language Center.

#### 2.4.2. U.S. Students

U.S. participants were 151 introductory psychology students at a selective public university who participated to fulfill their research requirement. As in Oman, slightly over half (55%) were males, and 40% were in their first year. In contrast to the Omani sample, however, gender and year in college were not associated. Racial ethnic distribution (of those reporting) consisted of 60% Caucasian, 22% Asian American, 9% African American, 4% Latino/a, and 5% other. Of those who reported their religious preference, 37% were Protestant, 23% Catholic, 11% Jewish, 5% Hindu, 1% Muslim, and 1% Buddhist, with 22% describing themselves as agnostic, atheist, or having no specific religion. The U.S. student sample is religiously heterogeneous, but virtually distinct from the Muslim dominated Omani sample.

As in Oman, U.S. students indicated their major (or intended major). For purposes of comparison, this information was used to classify U.S. students into groups that were approximately equivalent to the Omani categories. According to this scheme, as shown in Table I, the distribution of students according to science categories is 30% high, 28% moderate, and 40% low, which is somewhat comparable (especially in the low science category) to the Omani student distribution of 41%, 14%, and 44%, respectively.

### 3. Results

#### 3.1. DIMENSIONS OF EPISTEMIC BELIEFS

Omani and U.S. student responses to the 35 epistemology statements were analyzed separately by country to create psychometrically acceptable scales that represented the four intended knowledge and knowing belief dimensions proposed by Hofer and Pintrich (1997). After initial principal components extraction and varimax rotation, items that loaded appropriately were retained and reanalyzed, including forcing a four-factor structure (the initial extraction in both countries yielded 11 factors with eigenvalues  $>1$ ). Further scale refinement was then conducted to improve reliability (Cronbach  $\alpha$ ), and items were retained that formed internally consistent scales. Further factor analyses and rotation resulted in the sets of items with salient factor loadings ( $>0.40$ ) for each factor, which are shown in Table II. With few exceptions, final factor loadings and levels of internal consistency for the two countries are comparable. Reliability estimates range from 0.44 to 0.70 ( $Mean = 0.54$ ), which suggests that effects in the present study may be somewhat underestimated due to the lower than desired level of reliability, yet are comparable to estimates in other studies.

With regard to simple knowledge, the items that students responded to most consistently were stated in reference to complexity rather than simplicity. Similarly, on the certainty (stability) dimension, students responded more consistently to items stated in terms of change rather than certainty. For ease of interpretation, items on these two scales were reverse-coded so that higher values represent the degree to which students believed that knowledge is simple and certain, respectively. The factor best interpreted as justification consists of items that focus on what could be summarized as scientific methodology versus personal opinion, that is, belief in the extent to which there is an objective reality that can be discovered by reliable empirical means. The fourth factor, source, represents the degree of belief in authority as the arbiter of what is true. For further analysis, scales were computed by unit weighting the items (i.e., computing the mean of responses where strongly disagree = 1 through strongly agree = 5, with reversals as noted earlier). The resulting means and variances for these scales are presented in Table II.

#### 3.2. ASSOCIATION BETWEEN BELIEF DIMENSIONS

Table III presents correlations between the epistemology scales, with U.S. students above the diagonal and Omani students below the diagonal. As found in other studies, beliefs that knowledge is simple and certain are significantly correlated for both Omani ( $r = 0.24, p < 0.001$ ) and U.S. students ( $r = 0.18, p < 0.05$ ). As well, students in both countries with stronger beliefs that justification of truth is based on agreed-upon observation

Table II. Epistemic beliefs factor structure of Omani and U.S. University students

Belief Statement	Simple		Certain		Justification		Source	
	Oman	U.S.	Oman	U.S.	Oman	U.S.	Oman	U.S.
The truth in science consists of complexly related facts and ideas.*	0.68	0.68						
Scientific knowledge is complex.*	0.66	0.78						
Scientific ideas are related in complex ways.*	0.58	0.76						
What is known in science is complex rather than a set of simple facts.*	0.54	0.67						
What is considered the truth in science changes over time.*			0.71	0.81				
What is considered scientific truth is likely to change.*			0.66	0.81				
Principles of basic knowledge in science are open to revision.*			0.61	0.44				
Scientific knowledge is not well established or certain.*			0.62	0.53				
Investigators can justify their scientific knowledge using agreed upon methods.					0.73	0.62		
Scientific knowledge is based on whether researchers consistently arrive at the same conclusions					0.70	0.51		

Table II. continued

Belief Statement	Simple		Certain		Justification		Source	
	Oman	U.S.	Oman	U.S.	Oman	U.S.	Oman	U.S.
It is possible to discover what is true in scientific fields.					0.56	0.60		
Justification of knowledge in science is based on objective reality.					0.45	0.58		
People can accept the knowledge of scientific authorities without question.							0.70	0.79
A person can just accept answers from scientific experts without question.							0.69	0.71
If people read something in a science textbook, they can be confident it is true.							0.66	0.54
Derived scale descriptive statistics								
Mean	2.22	1.92	2.70	2.37	3.60	3.63	2.79	2.20
SD	0.66	0.68	0.75	0.70	0.60	0.63	0.90	0.76
Cronbach $\alpha$	0.49	0.70	0.55	0.60	0.46	0.44	0.57	0.54

Note: Oman sample  $n = 231$ , U.S.  $n = 151$ . Principal components extraction and varimax rotation; only loadings  $> 0.40$  are shown.

\*Items reverse coded so that higher values represent greater beliefs that knowledge in the sciences is simple and certain.

*Table III.* Correlations among epistemic belief dimensions for U.S. (above the diagonal) and Omani students (below the diagonal)

Variable	Simple	Certain	Justific.	Source
Simple		0.18*	-0.07	0.13
Certain	0.24***		0.20*	0.24**
Justification	-0.28***	-0.16*		0.17*
Source	0.06	-0.14*	0.23***	

\* $p < .05$ .

\*\* $p < .01$ .

\*\*\* $p < 0.001$ .

(i.e., justification) were more likely to trust authorities (i.e., source) in Oman ( $r = 0.23$ ,  $p < 0.001$ ) and the U.S. ( $r = 0.17$ ,  $p < 0.05$ ). There were also differences between countries, however, regarding the way certainty of knowledge (i.e., degree of stability versus change) related to justification and source. For U.S. students certainty of knowledge was directly related to these dimensions: the less knowledge in the sciences was thought to change (i.e., be the more certain), the more they believed truth is based on empirical evidence and the more they trusted authorities. Whereas the opposite held for Omani students; the more certain, the less they believed knowledge was based on evidence or trusted authorities.

We also examined relations between epistemic beliefs and student characteristics. A series of multiple regressions was employed to test the independent predictive contribution of gender, year, and experience with science to each of the four belief dimensions, separately by country. Standardized regression coefficients and significance levels are presented in Table IV. After controlling for year in school and exposure to science, Omani men more so than women were more likely to believe that knowledge is simple ( $\beta = -0.19$ ,  $p < 0.05$ ). The effect was not significant for U.S. students, although of comparable magnitude and direction. Effects of experience with science were similar for students in both countries: the more experience the stronger both Omani ( $\beta = 0.15$ ,  $p < 0.05$ ) and U.S. students ( $\beta = 0.22$ ,  $p < 0.05$ ) believed that scientific knowledge was unchanging. Of note is that effects of gender and degree of exposure to science-related curricula appear to have had comparable associations for students in both countries. Such was not the case for beliefs about the source of knowledge, which exhibit marked differences as a function of gender. Specifically, Omani men were more likely to accept scientific authority than were women ( $\beta = -0.28$ ,  $p < 0.01$ ), whereas if anything U.S. men were less likely to accede to authority

Table IV. Regression analysis of personal epistemic beliefs as a function of student characteristics

Student characteristic	Epistemic belief dimension							
	Simple		Certain		Justification		Source	
	Oman	U.S.	Oman	U.S.	Oman	U.S.	Oman	U.S.
Gender	-0.19*	-0.15	-0.07	-0.01	0.01	-0.09	-0.28**	0.09
Year	-0.13	-0.10	0.10	-0.14	-0.02	0.00	-0.06	-0.11
Science	-0.05	-0.01	0.15*	0.22*	-0.02	-0.04	-0.08	0.05
$R^2$	0.08	0.03	0.02	0.07	0.01	0.01	0.10	0.03
$F$	5.48***	1.33	1.56	3.27*	< 1.00	1.74	6.57***	1.07

\* $p < .05$ .

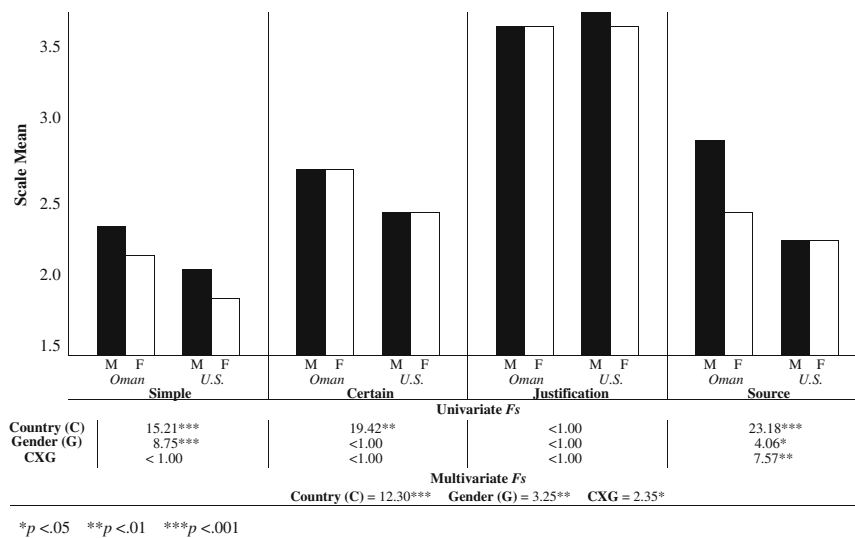
\*\* $p < .01$ .

\*\*\* $p < .001$ .

Note: Standardized regression coefficients are shown; gender is coded male = 1, female = 2; higher science values reflect having had more experience with science as inferred from college major (range = 1–3).

( $\beta = 0.09, ns$ ). It should be emphasized these differences remained even after controlling for year in school and experience with science. Finally, justification of knowledge (i.e., belief in empirical evidence) was not associated with any of the measured student characteristics.

For the primary analysis, which tested for the effects of country and gender, responses of Omani and U.S. students to the four epistemology scales were analyzed simultaneously using a Country X Gender multivariate analysis of covariance, followed by separate univariate analyses of covariance for each dimension, with year in school as a covariate. All multivariate effects were statistically significant, indicating that students' beliefs differed as a function of country ( $F_{\text{mult}} = 12.30, p < 0.001$ ), gender ( $F_{\text{mult}} = 3.25, p < 0.01$ ), and the interaction between country and gender ( $F_{\text{mult}} = 2.35, p < 0.05$ ). As shown in Figure 1, distinctly different effects were found for the four dimensions of epistemic beliefs. Specifically, Omani more so than U.S. students were likely to believe that knowledge is simple and certain. Male more so than female students in both countries believed that knowledge was simple, but there was no gender difference with respect to whether knowledge was certain. There were no country or gender effects for justification. Most important, however, the expected interaction between country and gender was found ( $F(1, 346) = 7.57, p < 0.01$ ). Whereas U.S. male and female students did not differ in their reliance on authority, gender did matter in Oman. Controlling for year in school, Omani men were more inclined to rely on authorities than



\* $p < .05$     \*\* $p < .01$     \*\*\* $p < .001$

Figure 1. Epistemic beliefs of male (M) and female (M) Omani and U.S. university students.

were Omani women. Overall, Omani students considered authorities more important ( $F(1, 346) = 23.18, p < 0.001$ ); however, the effect is clearly attributable to differences between male rather than female students in the two countries. It should be noted that the Country X Gender interaction confirms what was inferred from differences between Omani and U.S. students' regression coefficients for gender and source described previously (see Table IV).

#### 4. Discussion

We found detectable differences between aggregate responses of Omani and U.S. university students on three of the four dimensions of epistemic beliefs measured in the present study. The most important effects concern beliefs about authority, which of the epistemological dimensions measured in the present study is most closely linked to cultural characteristics of the two countries. This suggests that because of the more authoritarian structure of their society, Omani more so than U.S. students in general were willing to accept authorities' statements about scientific knowledge. The country difference was clearly a function of gender, however, in that Omani men were more accepting than were Omani women, a difference that was absent in U.S. students. More acceptance of authority by Omani men is consistent with their greater participation in political and religious affairs. As we conjectured, their experiences in authority-rich contexts in which others profess what is true, especially in the mosques, may create habits of reliance

on others, which generalizes to the domain of science. This interpretation supports the connection between general culture-based interpersonal relations and learning depicted by Schommer-Aikins's (2004) embedded systemic model of epistemic beliefs, in which asymmetrical interpersonal relations generalize to beliefs in certain knowledge domains and ultimately how students approach learning.

At the outset it was also uncertain whether Omani women college students would be more or less likely to accept authorities. As with Omani men they too are exposed to asymmetric interpersonal relations, albeit not to the same extent as Omani men in religious activities or other areas of Omani society (Rassekh, 2004). One reason why Omani women were less accepting of authorities may be attributable to selection factors – these represent the highly achieving women selected to attend the university. As summarized by Rassekh (2004) public policy has markedly accelerated Omani women's involvement in education. Possibly those taking advantage of increased opportunity are independent thinkers and more accomplished in general because of having overcome societal barriers to success. Observations by Strommer (2001) that “Beneath their black *abayas* and head scarves, most students were confident, assertive, and inquisitive [and] did not hesitate to seek information or assistance – or to let us know exactly how they felt about courses, instructors, or campus rules” (para. 2) supports this view of Omani women college students. More in-depth studies of Omani women, similar to studies of women in other cultures are suggested along the lines of those involving gender in the U.S. (e.g., Baxter-Magolda, 1992; Clinchy, 2002).

Our interpretation of the moderating effects of gender on country differences, or from the other perspective, of country on gender differences, suggests further studies that assess student characteristics that are indicated by the inferred cultural experiences. Most important would be to directly measure cultural and gender differences in the degree to which students have experienced authority. We could then test whether comparisons between cultures that differ in perceived salience of authority mediate differences in epistemic beliefs. This may also reveal relationships within each culture in much the same manner that individualism–collectivism accounts for variance within as well as between cultures (e.g., Triandis, 1995). Beyond such statistical comparisons, however, is the need to: (a) further examine in much greater depth students' experiences with and views of authority in general, and (b) whether and in what ways those experiences transfer (or do not transfer) to beliefs about knowledge in the sciences or other knowledge domains. In other words, more qualitative and phenomenological information is necessary for an in-depth examination of the issues suggested by the quantitative findings, similar to Al-Salhi's (2001) approach with Saudi Arabian students. Recent work by Raviv et al. (2003) on students' views of teachers as epistemic authorities is especially relevant.



With respect to other dimensions of epistemology, Omani more so than U.S. students believed that knowledge was both simple and certain. This is consistent with Qian and Pan (2002) who found that Chinese more than American students' believed that knowledge is simple and certain. Given the limited number of comparable studies it is difficult to know the extent to which this difference is generalizable, and even if so, whether it is attributable to cultural differences. In the present study, for example, in both Oman and the U.S., simplicity and certainty were directly related to students' experiences with science, or at least the degree to which they were in science curricula (see Table IV). This suggests that differences between cultures, such as found by Qian and Pan, may be explained by the relative degree of familiarity with science content and methodology. Accordingly, inclusion of domain familiarity should be assessed in subsequent studies to explore this possibility. Gender differences were evident for simplicity of knowledge. However, they were consistent across cultures. The absence of gender differences for certainty (as well as justification) is also consistent. Thus, the interaction between country and gender was absent from simple, certain, and justification dimensions of personal epistemic beliefs.

The relative absence of evidence about epistemic beliefs in Middle Eastern cultures, as compared to that available for Western and Asian cultures, invites further investigation. Challenges for future research include instrumentation equivalence and translation, even though there were few manifestly difficult translation problems in the present study. We believe that authority and gender are critical dimensions to study. But others require further attention as well, such as religiosity and even fundamentalism, which may be related to authoritarian worldviews (Altemeyer & Hunsberger, 1992). Ideal conditions for assessing such effects would be those in which cultures are in close proximity and share common or contiguous environments, such as currently exists in Israel, although with due regard to the differences between multi-cultural and mono-cultural contexts.

Also needed are further tests of the Hofer and Pintrich (2002) model of epistemic beliefs. Although measurement issues remain, and scale reliabilities in the present study were lower than desired, the dimensions assessed were conceptually clear compared to Al-Salhi's (2001) application of Schommer's Epistemological Beliefs Questionnaire. In agreement with Youn (1997), who found two factors with samples from South Korea and the U.S., one of Al-Salhi's dimensions combined simple, certain knowledge and authority, and the other, active learning. Such reliance solely on exploratory factor analysis, which can be a blunt instrument that homogenizes conceptual distinctions, would have failed to detect important effects in the present study. A combination of confirmatory analytic approaches and attention to construct validity is called for in future studies that adopt Hofer and Pintrich's model, which has much to recommend in appropriately assessing students' epistemological beliefs.

## Notes

<sup>1</sup>Terms used to describe areas of the world are not always consistent between or even within various literatures. The term Middle Eastern in the present context will refer to predominant Middle Eastern Muslim cultures, recognizing the regions' cultural-religious heterogeneity, in particular the State of Israel, and differences in the degree of religiosity among ostensibly Muslim-dominated countries.

<sup>2</sup>In addition to specific references provided, information about Oman was compiled from reports of the United Nations, U.S. Department of State, and Sultanate of Oman publications, especially the Oman Ministry of Higher Education *Book of Statistics 2001–2002* (2002). Descriptions of the culture and educational system are also based on personal experiences of the second author (Moosa) who served as Director, Educational Research Center, College of Education, Sultan Qaboos University, Muscat, Oman.

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