Us and Them: Differences in beliefs about knowledge across different academic disciplines

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Researchers (Jehng, Johnson & Anderson, 1993; Paulsen & Wells, 1998) have suggested that it is possible to divide disciplines into categories such as 'applied' vs 'pure'. They believe that significant differences exist between the epistemological beliefs of students studying 'applied' disciplines to those studying 'pure' disciplines. This study looked at students studying in five different academic disciplines. Using Hofer's (2000) Epistemological Belief's Questionnaire (EPQ) the analysis compared the disciplines on four factors. A MANOVA confirmed that different significant differences existed on three of the four factors (Certainty df=4, F=113.65, p< 0.001; Justification: personal df=4, F=45.31, p<0.01; Source: authority df=4, F=12.433, p< 0.001; Justification: experience df=4, F=0.685, p=0.904). Post-hoc analysis revealed the pattern of differences was consistent with the previous theories. 'Applied' students viewed knowledge as certain, coming from an authority and not to be evaluated personally , compared to their 'pure' counterparts. Results are discussed regarding the reliability of the EPQ and implications to teaching and learning in these disciplines.

THE TERM epistemology refers to the set of beliefs an individual has about knowledge, including such things as where knowledge can be found and how to evaluate it. For example, the statement 'No theory in Psychology is irrefutable' represents the epistemological belief that knowledge in Psychology is never certain. Perry (1970) introduced the concept of epistemological development as a process that students in Higher Education undergo, where their beliefs about knowledge change over the course of their time in Higher Education. Perry believed that a student's epistemological beliefs progressed from simplistic beliefs at the start of their undergraduate studies, to more sophisticated beliefs by the time they reached postgraduate level. Epistemological development is relevant to the learning process as an indicator of cognitive development and sophistication. The more sophisticated an individual's epistemological beliefs, the more capable they would be at handling complex concepts, which in turn would make them a more capable student. Indeed, various studies have shown links between an individual's level of epistemological development and type of study strategies they employ (Schommer, Crouse & Rhodes, 1992), their motivation for learning (Buehl, 2003) as well as their levels of active learning and conceptual understanding (Linn & Songer, 1993; May & Etkina, 2002). In addition to this. it has been suggested that by promoting an individual's epistemological development we could enhance their learning ability (Hofer, 2001; Gill, Ashton & Algina, 2004).

Since Perry's original research there have been a considerable number of studies looking into this process, debating the number of stages or when the process begins. Some researchers, such as Schommer (1990; 1994), Schommer, Crouse and Rhodes (1992) and Hofer and Pintrich (1997) have moved away from looking at epistemology in terms of developmental stages. Instead they propose that each individual has a set of epistemological beliefs, each of which could be seen as a distinct dimension. In Hofer and Pintrich's (1997) model, for example, they propose four dimensions. The first dimen-

sion, Certainty, represents the degree to which we believe knowledge to be either fixed and unchanging or fluid and changeable. The statement in the first paragraph regarding refuting theories in Psychology is an example of a belief at the 'fluid and changeable' end of this dimension. The second dimension, Source, represented the degree to which we believe knowledge to originate either inside or outside of the self. The third dimension, Simplicity, represents the degree to which we believe knowledge to be either a collection of separate facts or a series of interconnected concepts. Finally, the fourth dimension, Justification, represents the degree to which we believe that knowledge can be evaluated either by direct experience and authority or by some form of rules of evaluation.

One issue under debate in epistemological research concerns the degree to which an individual's epistemological beliefs are context dependent. Early studies presented an image of an individual's epistemology as context independent, related only to their stage of epistemological development (Perry, 1970). Since then a number of researchers have found significant differences when comparing the epistemological beliefs of students in one subject area with the beliefs of students in a different subject area (Jehng, Johnson & Anderson, 1993; King & Kitchener, 1994; Paulsen & Wells, 1998). These findings would indicate the existence of a domain specific profile of epistemological beliefs that is shared by the those studying that domain. This would support the idea of context dependency in epistemological beliefs, suggesting that there is a relationship between what a student is studying and their epistemological profile.

More recent research has tried to expand on this idea of context dependence. They have suggested that one individual who has studied two disciplines could hold two completely independent sets of epistemological beliefs, one for each knowledge domain. A number of researchers have carried out studies using a within-participant design, looking at the same individual's beliefs regarding more than one knowledge domain. They have confirmed that the same individual can have multiple independent sets of epistemological beliefs, in essence a different epistemological profile for each knowledge domain (Schommer & Walker, 1995; Hofer, 2000; Buehl *et al.*, 2002). The relevance of this particular issue to education is clear when we consider that most students are being asked to study a number of different disciplines, each of which might be seen as a knowledge domain. As such the degree to which an individual's epistemology is shaped by the knowledge domains they encounter and whether this results in multiple epistemological profiles is of great significance if we hope to understand the relationship between epistemology and learning.

Of the studies that have examined the context dependence of epistemological beliefs, the majority have used Schommer's (1990) model of epistemological beliefs as the basis for their measure of epistemology. One of the issues with Schommer's model is that it includes measures of belief in the speed of learning and the innateness of learning ability. To some researchers these elements should not be included in a measure of epistemology. They see them as representing beliefs regarding Learning as opposed to Knowledge, which would differentiate them from epistemological beliefs (Hofer, 2001). Hofer and Pintrich's (1997) model, described earlier, was developed from Schommer's model, but does not include the measures of belief in the speed and innateness of learning. For this reason we decided to use Hofer's (2000) questionnaire, which is based on Hofer and Pintrich's (1997) model, as the basis for the measure used in this study.

In her study Hofer (2000) developed an epistemological beliefs questionnaire to compare the same individual's beliefs regarding Psychology and Science. While Hofer did show evidence of two separate epistemological profiles for these two areas

within the individual, there is the possibility of a serious confounding issue in her design. Some critics felt that 'Science' was too broad a category, containing many different subdomains, to be considered comparable to the single domain of Psychology (Buehl *et al.*, 2002). With no idea of which subdomains each individual is including in their concept of 'Science' it introduces the possibility of considerable variation between participants which may influence our findings if we were to attempt to compare it to Psychology. As Buehl *et al.* (2002) recommend, it would be better if Psychology had been compared to a single scientific domain (e.g. Chemistry) than to the entire discipline of 'Science'.

To summarise, this study's general aim is to investigate the context dependent view of epistemological beliefs using Hofer and Pintrich's (1997) model. In the first phase we would aim to establish whether students studying different academic disciplines have significantly different epistemological profiles (King & Kitchener, 1994; Paulsen & Wells, 1998). In the event that this is successful then in the second phase we aim to investigate the findings of Hofer (2000) that the same individual can hold several independent sets of epistemological beliefs. Here we also aim to overcome some of the design issues with Hofer's study by comparing two knowledge domains (i.e. Psychology and Health studies) rather than comparing a domain and an entire discipline (i.e. Psychology and 'Science').

Method

Participants

The participants selected for this study were students in their first year in university. The age range for the entire group was between 17–22, with a mean age of 20.5 and a ratio of 1:2 for men to women. All of the students involved were taking a combined honours degree, requiring them to split their studies between two different disciplines. The sampling approach used was opportunity sampling, based on the fact that the students were approached at the beginning of one of their lectures in the relevant subject. In terms of the five disciplines involved in the study the following number of students participated: Psychology (n=118); Sociology (n=86); Theology (n=25); Health Studies (n=39); and Law (n=18).

Materials

The measure we employed was based on the domain specific epistemological beliefs questionnaire used by Hofer (2000). In terms of a factor structure, Hofer (2000) originally theoretically laid out a four factor structure in her introduction. Based on Hofer and Pintrich (1997) it identified her four factors as the Certainty, Simplicity, Source and Justification for knowledge. However, she did not provide any *a priori* indication as to which items in her questionnaire would load onto each of the factors. Instead her factor structure and loadings were established in a *post hoc* exploratory factor analysis. Only 18 of the original 27 items loaded above the 0.30 level. While the resulting factor structure did have four factors, the description of the nature of those factors bore only a limited similarity to those outlined in her introduction. In the case of two of her original dimensions, Source and Justification, Hofer had narrowed her definition of what they measure. In the case of one dimension, Simplicity, it is dropped altogether and replaced with a completely new dimension, Attainment of truth, for which she offers little in the way of a theoretical basis.

The resulting factors were Certainty; Justification: personal; Source: authority; and Attainment of truth. The Certainty factor represented the degree to which that individual believes knowledge to certain and permanent in that subject. The Justification: personal factor represented the degree to which they believe that only they themselves can judge the validity of knowledge. The Source: authority factor represented the degree to which they believe the source of knowledge as originating from an authority figure. Lastly the Attainment of truth factor

represented the degree to which they believe that a definitive truth or final answer will be achieved to questions in that subject. In each case a high overall score on that factor total would indicate agreement with that concept and a low over score indicates disagreement.

It was this shorter 18-item version of Hofer's (2000) questionnaire that we used in this study. Each item represents a statement of belief to which the participant could indicate their level of agreement using a five-point Likert scale, ranging from 'Strongly Agree' to 'Strongly Disagree'. Hofer (2000) was concerned that some of the items might not have been 'meaningful' to freshman students. As such we reviewed the questions and minor changes were made the wording of some questions (see Appendix A). In each case the aim was to clarify what the question was asking without changing the meaning.

The overall layout of the questionnaire was such that the front page could be modified depending on which subject the student was being asked about. It would ask the student to focus on that subject alone when answering the questionnaire. The actual questionnaire then asked the student about their epistemological beliefs regarding the subject that had been mentioned on the front cover. The order of the questions was varied from subject to subject in an attempt to reduce any possible practice effect that might result when the same individual filled in the questionnaire for the second time.

Using the data gathered in the main study a *post hoc* exploratory factor analysis was carried out. The aim was to compare the resulting factor structure with Hofer's (2000), both in terms of number and type of factors as well as reliability scores. Based on Hofer (2000) the factor analysis used a principle components procedure and Varimax rotation. Using the Kaiser–Guttman rule (Guttman, 1954; Kaiser, 1960) of extracting factors with an eigenvalue greater than one, a five factor structure emerged. These factors represented the following dimensions: Certainty; Justification: personal; Source: authority; Attainment of truth; and Justification: experience. As we can see all four of Hofer's (2000) factors have emerged, although there is an additional factor which we have named Justification: experience, based on the items the load on it. This factor represented the degree to which an individual believes that personal experience is a valid justification for knowledge. It should noted that a few of the items now load onto different factors in this study than they did in Hofer's. None the less there is considerable similarity between our factor structure and Hofer's.

Following this a series of Cronbach's Alpha reliability analyses were conducted, looking at the reliability of the various dimensions. The results are summarised in Table 1 and compared with the alpha levels reported by Hofer (2000) where relevant.

As we can see the reliability scores for almost all the factors were comparable to the corresponding scores in Hofer's (2000) study. Furthermore, although it had not

Table 1: Comparison of the Cronbach's Alpha results with those reported in Hofer (2000)

Factors	Current Study	Hofer (2000)	
	(n=287)	Psychology (n=326)	Science (n=147)
Certainty	$\alpha = 0.66$	$\alpha = 0.74$	$\alpha = 0.81$
Justification: Personal	$\alpha = 0.57$	$\alpha = 0.56$	$\alpha = 0.61$
Source : Authority	$\alpha = 0.52$	$\alpha = 0.51$	$\alpha = 0.64$
Attainment of Truth	$\alpha = 0.43$	$\alpha = 0.60$	$\alpha = 0.75$
Justification: Experience	$\alpha = 0.61$	–	–

Note: No values available for the 'Justification: experience' factor from Hofer (2000) as this factor did not appear in that study's factor structure.

appeared in Hofer's factor structure, the relatively high reliability for Justification: experience convinced us to retain it for use in our further analysis. On the other hand the Attainment of truth factor's alpha score of 0.43 was considered unreliable and as such that factor and the items loading on it were not included in any further analysis.

Design

The design employed was a mixed-methods design. The independent variable was the subject being studied and the dependent variables were the totals for each of the four dimensions Certainty, Source: authority, Justification: personal, and Justification : experience. The comparison of the epistemological beliefs scores of participants studying the five different courses (Psychology, Sociology, Theology, Health Studies and Law) was a between participants design. The comparison of the epistemological beliefs scores for individuals studying both Psychology and Health Studies was a within participants design.

Procedure

We approached the students at the start of a lecture for the foundation module in one of their disciplines. This was done in an attempt to catch the student at a time in which that subject was foremost in their mind. We explained the purpose of the study and they were then invited to complete the questionnaire, answering each question with regard to that subject only. The students were assured of confidentiality, they were offered the option to ask questions and it was made clear that they were under no obligation to participate and had the right withdraw without penalty at any time. Once the questionnaires were completed they were collected and we thanked the students for their participation.

This process was repeated for some of the students who were approached twice, once for each of the two disciplines they were taking. The lectures that were chosen were spaced out to ensure that no student was approached twice in the same week in an attempt to reduce any practice effects. Similarly we cautioned the students that in the event they had previously completed the questionnaire for another subject, they should disregard the answers they have given on that previous occasion and focus on the subject they were currently in.

Results

The data consisted of each individual's responses to the items on the questionnaire, which were measured on a five-point Likert scale for each item. The totals for each of the four factors were calculated by summing the responses to the items related to that dimension. In some cases an individual produced two sets of scores, one for each of the two disciplines they are taking.

The first stage of the analysis involved a MANOVA with subject being studied as the independent variable and each of the four factor totals as dependent variables.

Table 2: Mean scores for the four factors presented by subject area

Subject	N	FACTORS			
		Certainty	Justification: personal	Source: authority	Justification: experience
Psychology	118	8.25	14.77	13.01	6.25
Sociology	87	8.41	15.21	12.62	6.37
Health	39	11.05	13.41	14.59	6.33
Law	18	12.22	13.06	16.33	6.44
Theology	25	8.40	16.04	10.96	6.04
Total	287	8.94	14.72	13.14	6.29

Table 3: MANOVA comparing responses of students from different disciplines on the four dimensions of epistemological beliefs

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Subject	Certainty	454.623	4	113.656***	19.050	[a] <0.001
	Justification: Personal	181.262	4	45.316***	6.854	[a] <0.001
	Source: Authority	409.830	4	102.458***	12.433	[a] <0.001
	Justification: Experience	2.741	4	0.685	.259	0.904
Error	Certainty	1682.485	282	(5.966)		
	Justification: Personal	1864.438	282	(6.611)		
	Source: Authority	2323.870	282	(8.241)		
	Justification: Experience	746.674	282	(2.648)		

Note. Values enclosed within parentheses represent mean square errors.
*** $p < 0.001$
[a] Indicates a significance of greater than $p < 0.001$, abbreviated to $p < 0.001$ for the purposes of formatting.

The results indicate that in three for the four factors there was a significant difference between two or more of the disciplines on the epistemological beliefs of the students taking those disciplines. As such a *post hoc* analysis was required, which assessed where differences between the various disciplines lay on each of the three dimensions. The test used was the Bonferroni method and the results are summarised in Table 4.

On all three factors we see a similar pattern emerge, the disciplines gathered into two significantly different groups. One group consists of Health and Law, the other consisting of Psychology, Sociology and Theology. If we consult the mean scores in Table 2 we see that students studying Health and Law view knowledge as more certain, as coming from authority and are less likely to use personal judgement as a justification, than

Table 4: Significance levels of the post-hoc multiple comparisons on three of the four factors

		Certainty	Justification: personal	Source: authority
Psychology	Sociology	1.000	1.000	1.000
	Health	[a]<0.001***	0.045*	0.031*
	Law	[a] <0.001***	0.088	[a] <0.001***
	Theology	1.000	0.258	0.013*
Sociology	Health	[a] <0.001***	0.003**	0.004**
	Law	[a] <0.001***	0.014*	[a] <0.001***
	Theology	1.000	1.000	0.113
Health	Law	0.936	1.000	0.339
	Theology	[a] <0.001***	**0.001	[a] <0.001***
Law	Theology	[a] <0.001***	**0.002	[a] <0.001***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
[a] Indicates a significance of greater than $p < 0.001$, abbreviated to $p < 0.001$ for the purposes of formatting.

the other three disciplines. This supports the idea of significantly different discipline related epistemological profiles.

The second phase of the analysis involved the comparison of the two sets of scores for those individuals who were studying both Psychology and Health and as such completed the questionnaire twice. Psychology and Health were chosen as a significant difference had been found when comparing these two disciplines in the post-hoc analysis. Unfortunately there were very few participants who combined these two disciplines (n=14). As such the data for these individuals was analysed to ensure no evidence of outliers or skewness which might have a significant influence on results in the case of such a small sample. The Justification: Experience factor alone showed evidence of outliers and as such it was disregarded, the T-tests being carried out on the other three. The results are summarised in Table 5.

The results of this analysis indicate that there was no significant difference between the two sets of scores on any of the three factors. This would indicate that students studying both of these two disciplines did not show evidence of two significantly different sets of epistemological beliefs. These findings should be treated with caution though, owing to the fact that there is a small number of participants in this section of the research.

Discussion

The results of the analysis were mixed. The results of the first phase showed that the epistemological beliefs of students studying a given subject were significantly different to the beliefs of students studying other disciplines. The results of the MANOVA showed significant differences between the disciplines on three of the four factors, with the post-hoc analysis revealing considerable variation in terms of which disciplines differed and on which factor. This supports the view that an individual's epistemological beliefs are influenced by the subject they are studying (King & Kitchener, 1994; Paulsen & Wells, 1998). On the other hand, the results from the second phase showed no significant difference in the epistemological beliefs that student studying two disciplines had about each of the disciplines they were studying. As such we were unable to support the findings of Hofer (2000) that the same individual might hold more than one set of epistemological beliefs.

One issue that must be addressed before any other is the reliability of the questionnaire. The factor structure that emerged showed considerable similarity to Hofer's (2000). The results of the reliability analysis also indicate similar levels of reliability to those reported in Hofer (2000) for three of the four factors that emerged in both studies. The factor which did not show a similar level of reliability was the Attainment of Truth factor. It is not surprising that this factor showed low reliability, given its lack of any real theoretical basis. It is not identified theoretically by Hofer prior to her own analysis and is simply a label given to an unexpected and thus unidentified factor that emerged from that analysis. This practice of labelling a factor *post hoc* which has no theoretical basis is one of the weaknesses of the exploratory factor analytic process. With no theoretical basis behind them there is no reason to expect that factors that are identified in this way will show any kind of test-

Table 5: Dependent T-Tests comparing epistemological beliefs in Psychology and Health

	Mean Psych	Mean Health	t	df	Sig. (2-tailed)
Certainty	7.86	11.00	2.32	13	0.06
Justification: personal	14.14	13.00	1.19	13	0.28
Source: authority	14.71	13.71	1.32	13	0.23

retest reliability. This is something that must be kept in mind for the Justification: Experience factor that emerged as part of this study.

With items moving from one factor to another and entire factors appearing and disappearing there is a question mark over the degree to which the factor structure identified in this study can be said to confirm that found in Hofer (2000). There is also insufficient correspondence between the emerging factor structures in either studies and those being proposed theoretically in Hofer and Pintrich (1997). A number of different explanations have been offered to explain this difficulty replicating factor structures in this area of research. Some researchers such as Bromme (2005) argue that theoretical issues, such as poor understanding of the nature of epistemological beliefs, have led to poor item selection and questionnaire design. Others such as Buehl *et al.* (2002) have questioned the use of exploratory factor analyses as a method of validating proposed factor structures, arguing that confirmatory analyses be used instead.

In the final analysis the questionnaire is a flawed tool, but these flaws do not totally undermine the validity of the entire questionnaire. Certain elements, such as the Certainty factor, remain moderately robust and as such it is possible to draw tentative conclusions from the data they provide, while results arising from the less reliable elements such as the Justification: experience factor should be treated with more caution.

Keeping this in mind, the next step is to look at the issue of context dependent epistemologies as analysed by the MANOVA. Overall, significant differences were found between the disciplines on three of the four dimensions (Attainment of truth having been excluded due to low reliability). In order to determine the exact nature of these differences a *post hoc* analysis was conducted, and the results present a fascinating picture.When we come to those disciplines that differ significantly to those that don't, on all three dimensions we see a similar pattern of Health and Law on one side and Psychology, Sociology and Theology on the other (see Tables 2 and 4). Students studying Health and Law seem to view knowledge as more certain, as coming from authority, and are less likely to use personal judgement as a justification than the other three disciplines. There are two exceptions to this pattern, with Theology significantly more likely than Psychology to see knowledge as coming from external authority and Psychology not being significantly different to Law in the use of personal justification for knowledge.

As such the final picture then seems to be something of a continuum. At one end we find the disciplines seen as more fact and authority based, such as Health and Law. At the other end are those disciplines where knowledge is seen as more uncertain and interpretation- or personal opinion-based, such as Sociology and Theology. Psychology seems to be somewhere in the middle, although definitely more towards the Sociology/Theology end. There is a parallel between these findings and those of Jehng *et al.* (1993). who classified disciplines as either 'hard' or 'soft' depending on whether they felt the subject was more applied or theoretical respectively. They found that students studying 'hard' fields (e.g. business, engineering) saw knowledge as being more certain and were less likely to rely on their own judgement than those in 'soft' fields (e.g. humanities, social sciences). If we see Health Studies and Law as 'hard' fields and the other three as 'soft', there is a strong parallel between our finding and theirs. This may also help explain Psychology's position towards the middle, containing elements of both theory and application, it combines elements of both 'hard' and 'soft' fields.

The other interesting finding is to contrast the MANOVA results comparing Psychology and Health between participants, with the dependent t-tests comparing the same two disciplines within participants. As we have seen, in all three of the four dimensions the MANOVA indicated a significant difference between the epistemology of Psychology stu-

dents and their Health counterparts. However, this difference did not appear in the result of the dependent T-tests, which compared scores on three of the four dimensions for those individuals who study both disciplines. This would suggest that the students who combine the two disciplines seem to have more similar epistemological beliefs for each of the two disciplines than students who only study one or the other.

This finding fails to support Hofer (2000) who found that each student had two significantly different epistemological profiles, one for Psychology and one for Science. On the other hand our results seem to support Buehl *et al.*'s (2002) criticism that Hofer's result may have been due to her comparing a single knowledge domain to an entire discipline (i.e. Psychology and 'Science'). Another potential interpretation is that the act of starting to study both disciplines at the same time has resulted in those students developing similarities in their epistemological view of both disciplines. Hofer (2000) did acknowledge the possibility that domain specific epistemologies might interact. It might be necessary to examine students' epistemological beliefs regarding a new subject they are just starting with their beliefs regarding an older subject they have studied previously.

One potential weakness with these results was that the data for the t-tests comes from participants who filled in the questionnaire twice, possibly resulting in a practice effect and thus explaining the lack of difference. However, we must remember that a considerable number of the participants may have filled in the questionnaire twice, although not necessarily for the same two disciplines. As such if it were a practice effect we should see no significant difference between any of the disciplines. A more serious concern is that the sample size for those participants studying both Psychology and Theology was quite small (n=14). In addition given that it was an opportunity sample there may have been additional factors which caused those individuals to be present on both testing occasions and which might have influenced the results, such learning style or motivation.

This study represents the first in a series of studies in this area. The next step is to examine the impact of the epistemology behind the disciplines themselves. The impact of a lecturer's perceptions of learning and teaching on their teaching are well documented (Gow, Kember & Sivan, 1992; Kember, 1997). Some studies have considered how a teacher's beliefs about learning might influence a student's epistemological development (Sheppard & Gilbert, 1991; Kember, 2001). Others have suggested that a teacher's epistemological beliefs might even influence the design and delivery of the courses themselves (Gill, Ashton & Algina, 2004; Schraw & Olafson, 2003). This idea of a teacher's epistemology coming through in the design and delivery of a course could be described as the Epistemological Philosophy behind the course. One issue that has yet to be investigated is the possibility that the epistemological philosophy behind a course and the epistemologies of the students taking that course might interact. The results of that interaction might influence performance on assessments or even areas such as perceived satisfaction and belonging, which in turn could affect student retention. This would make the understanding of epistemologies in both students and staff of great practical implication to any department or course.

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References

Bromme, R. (2005). Thinking and knowing about knowledge: A plea for and critical remarks on psychological research programs on epistemological beliefs. In M. Hoffmann, J. Lenhard & F. Seeger, (Eds.) *Activity and sign – Grounding mathematics education.* (pp. 191–201). New York: Springer.

Buehl, M. (2003). At the crossroads: exploring the intersection of epistemological beliefs, motivation, and culture. Paper presented at the annual meeting of the American Educational Research Association. In H. Fives (Chair), *Internationalising the study of epistemological beliefs, goal orientations, and self efficacy*, April, 2003, Chicago.

Buehl, M.M., Alexander, P.A. & Murphy, P.K. (2002). Beliefs about schooled knowledge: Domain specific or domain general? *Contemporary Educational Psychology, 27*, 415–449.

Gill, M., Ashton, P. & Algina, J. (2004). Changing preservice teachers epistemological beliefs about teaching and learning in mathematics: An intervention study. *Contemporary Educational Psychology, 29*(2), 164–185.

Gow, L., Kember, D. & Sivan, A. (1992). Lecturer's views of their teaching practices: Implications for staff development needs. *Higher Education Research and Development, 11*(2), 135–149.

Guttman, L. (1954). Some necessary conditions for common factor analysis. *Psychometrica, 19*, 149–461.

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

Hofer, B.K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary Educational Psychology, 25*, 378–405.

Hofer, B.K. (2001). Personal epistemology research: Implications for learning and teaching. *Journal of Educational Psychology Review, 13*(4), 353–383.

Jehng, J.C., Johnson, S.D. & Anderson, R.C. (1993). Schooling and students' epistemological beliefs about learning. *Contemporary Educational Psychology, 18*, 23–35.

Kaiser, H.F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement, 20*, 141–151.

Kember, D. (1997). A reconceptulisation of the research into university academics' conceptions of teaching. *Learning and Instruction,* 7(3), 255–275.

Kember, D. (2001). Beliefs about knowledge and the process of teaching and learning as a factor in adjusting to study in higher education. *Studies in Higher Education, 26*(2), 205–221.

King, P.M. & Kitchener, K.S. (1994). *Developing reflective judgement: Understanding and promoting intellectual growth and critical thinking on adolescents and adults.* San Francisco: Jossey–Bass.

Kitchener, K.S. & Kitchener, K.S. (1981). Reflective judgement: Concepts of justification and their relationship to age and education. *Journal of Applied Developmental Psychology, 2*, 89–116.

Linn, M.C. & Songer, N.B. (1993). How do students make sense of science? *Merrill-Palmer Quarterly-Journal of Developmental Psychology, 39*, 47–73.

May, D.B. & Etkina, E. (2002). College physics students' epistemological self-reflection and its relationship to conceptual learning. *American Journal of Physics, 70*, 1249–1258.

Paulson, M.B. & Wells, C.T. (1998). Domain differences in epistemological beliefs of college students. *Research in Higher Education, 39*(4), 365–384.

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

Qian, G. & Alvermann, D. (1995). Role of epistemological beliefs and learnt helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology, 87*(2), 282–292.

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

Schommer, M. (1994). An emerging conceptualization of epistemological beliefs and their role in learning. In R. Garner, & P. A., Alexander (Eds.), *Beliefs about text and instruction with text* (pp. 25–40). Hillsdale, NJ: Erlbaum.

Schommer, M., Crouse, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology, 82,* 435–443.

Schommer, M., & Walker, K. (1995). Are epistemological beliefs similar across domains? *Journal of Educational Psychology, 87*(3), 435–443.

Schraw, G., & Olafson, L. (2003). Teachers' epistemological worldviews and educational practices. *Issues in Education, 8*(2), 99–148.

Sheppard, C., & Gilbert, J. (1991). Course design, teaching method and student epistemology. *Higher Education, 22,* 229–249.

Appendix A

Revisions to Hofer's (2000) discipline specific epistemological beliefs questionnaire. Revisions are shown in bold text.

HOFER (2000) ORIGINAL WORDING	REVISED WORDING
Truth is unchanging in this subject.	**What is considered true in this subject doesn't change.**
In this subject, most work has only one right answer.	In this subject, most work has only one right answer.
Sometimes you just have to accept answers from the experts in this field, even if you don't understand them.	Sometimes you just have to accept answers from the experts in this field, even if you don't understand them.
All professors in this field would probably come up with the same answers to questions in this field.	**If asked,** all professors in this subject would probably come up with the same answers to questions in this subject.
If you read something in a textbook for this subject, you can be sure it is true.	If you read something in a textbook for this subject, you can be sure it is true.
Most of what is true in this subject is already known.	**Most of the important truths in this subject have already been established.**
In this subject, it is good to question the ideas presented.	In this subject, it is good to question the ideas presented.
Correct answers in this field are more a matter of opinion than fact.	Correct answers in this field are more a matter of opinion than fact.
If scholars try hard enough, they can find the answers to almost anything.	If scholars **in this subject** try hard enough, they can find the answers to almost anything.
Experts in this field can ultimately get to the truth.	Experts in this field can ultimately get to the truth.
Principles in this field are unchanging.	**The basic principles that make up this subject** are unchanging.
If my personal experience conflicts with ideas in the textbook, the book is probably right.	If my personal experience conflicts with ideas in the textbook, the book is probably right.
There is really no way to determine whether someone has the right answer in this field.	**For the majority of questions in this subject** there is really no way to determine whether someone has the right answer.
Answers to questions in this field change as experts gather more information.	Answers to questions in this field change as experts gather more information.
All experts in this field understand the field in the same way.	All experts in this field understand the field in the same way.
I am more likely to accept the ideas of someone with first-hand experience than the ideas of researchers in this field.	I am more likely to accept the ideas of someone with first-hand experience than the ideas of researchers in this field.
I am most confident that I know something when I know what the experts think.	I am most confident that I know something when I know what the experts think.
First-hand experience is the best way of knowing something in this field.	First-hand experience is the best way of knowing something in this field.

Note. Text in bold indicates changes, all other test retains the same wording as found in Hofer (2000)