Student Views of Learning in a First Semester College Physics Course: A Study Using Q Methodology

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Abstract. *The purpose of this study is unique in its use of Q methodology to examine how students' personal epistemological views compared to how their instructor perceived their views. The ability to determine the differences and similarities in these epistemological views have implications for further research associated with learning (Halloun & Hestenes, 1998; May & Etkina, 2002; Schommer, 1993b) and instructor attitudes towards students. A variety of research methodologies have been employed to determine epistemology (Duell & Schommer-Aikins, 2001) including a number in physics (diSessa, 1993; Halloun & Hestenes, 1998; Hammer & Elby, 2003; Lising & Elby, 2005; Roth & Roychoudhury, 2003), but none have used Q methodology. This study demonstrated that Q is an effective way to reveal the multiple epistemological views in a classroom.*

Introduction

The purpose of this study was to demonstrate that Q methodology offers an efficient way to reveal the multiple epistemological views in a classroom which, in this study, was a first-semester college physics class. In addition, this study is unique in its use of Q methodology to examine how students' epistemological views compared to how their instructor perceived their views (both as ideal students and as typical students). A variety of studies indicate that student epistemological views have important implications for student learning and instruction (Schommer, 1993b), including specific studies in physics (Halloun & Hestenes, 1998; May & Etkina, 2002). Hammer (1997) stated that if instructors can identify their students' personal epistemological beliefs, those instructors can then adapt plans and strategies for addressing students' needs and behaviors. Similarly, instructors' views of learning and knowledge affect both their teaching methodologies and the learning of students in their classes (Prosser & Trigwell, 1999).

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Prosser (2000) found that the learning of science concepts can be affected by epistemological views. In addition, Daniels (2001) found that instruction can change student epistemology. Thus, numerous studies indicate the importance of determining epistemological views of learning and knowledge of both instructors and their students. Although Q methodology would seem an appropriate method for investigating the epistemological views of students relative to their instructors, a review of the literature did not reveal any other Q study specifically examining epistemology.

Instead, a variety of other research methodologies have been employed to determine epistemology. The study of personal epistemology began with in-depth interviews to elaborate on epistemological development and this approach has remained popular (Duell & Schommer-Aikins, 2001). These types of investigations of students' personal epistemology have been common in physics education research (Lising & Elby, 2005) as well as other science education research (Hofer, 2004).

The use of Likert-scale surveys for a more objective means of assessing epistemological beliefs started in the mid-1980's with a study of the relationship between student epistemology and reading comprehension (Ryan, 1984). In physics, the six-dimension, Likert-scale Views About Sciences Survey (VASS) has been used to investigate student epistemology in conjunction with their views on the nature of science (Halloun & Hestenes, 1998). One of the most popular Likert-scale surveys was developed by Schommer (1990) to effectively and efficiently determine student epistemological views. Duell and Schommer-Aikins (2001) reported that the Schommer 1990 survey was both valid and reliable. Using R-factor analysis with Varimax rotation and principal components extraction, Schommer found that the epistemology survey she created contained four factors: Ability to learn is innate, Knowledge is discrete and unambiguous, Learning is quick or not at all, and Knowledge is certain. In this way, she then described personal epistemology as consisting of these four dimensions, opposed to one single view. She used these dimensions in regression analyses to investigate the relationship between students' knowledge on specific tasks and each of these factors. Specifically related to our study, the Schommer survey has been used in a number of studies to investigate post-secondary learner views of knowledge and learning (Chan & Elliott, 2004; Jehng, Johnson, & Anderson, 1993; Schommer, 1990; Schommer, 1993a).

Interviews and other purely qualitative techniques are time consuming. And, as McKeown (2001) stated, Likert-scale evaluations and rank orderings lead to the loss of meaning. Q is well suited for the purposes of our study, which are determining the individual differences among the various students' views of learning and knowledge and comparing these views with the views of the course instructor. As previously stated, determining students' and instructors' epistemological views has implications for both teaching and learning. Thus, Q methodology was selected for epistemological study because alternatives for determining such perspectives are not as powerful as Q (McKeown, 2001).

Methodology

The starting point for this study was the development of a concourse of items followed by selection of the Q sample. Our original concourse of statements consisted of the 67 statements from Schommer's (1990) Likert-scale survey. An initial study (Ramlo, Thompson, & Kaut, 2006) used a Q sample that consisted of 32 of these 72 statements. However, this pilot study revealed several issues related to the use of these statements' format.

The results and students' written comments from the pilot study indicated that students typically sorted the Schommer statements based not upon their personal epistemological views but, instead, based upon their public epistemology. Lising (2005) differentiated these views by describing personal epistemology as how someone perceives their own learning and knowledge. Alternatively, someone's public epistemology represents how they view others' epistemology such as scientists or other authorities. Similar to this differentiation of epistemology types, I concluded that students sorted the pilot-study version of the Q sample based upon a more general view of how others perceive learning and knowledge, not based upon their own personal view of their learning and knowledge. In part, this seemed to be a function of the wording of the statements which used impersonal language such as "Getting ahead takes a lot of work." Therefore, I changed the wording of the original Schommer statements in the study reported here to make them more personal. For example, "Learning something really well takes a long time" was changed slightly to "Learning something really well takes me a long time in this course" in order to stress to students that they were to reflect on their own personal epistemology relative to the first-semester physics course they were taking. Similarly, "I don't have to work hard to learn" replaced the earlier "The really smart students don't have to work hard to do well in school." In addition, student feedback revealed that students felt that many of the Schommer statements were similar. Ten of these Schommer statements were then removed from the Q sample. To replace these statements and to increase the Q sample size, student interviews were used to develop additional statements.

The revised Q sample allowed the researcher to better investigate students' personal epistemologies. This new Q sample contained 44 statements with 22 of these statements from student interviews. The remaining 22 statements were revisions of the Schommer survey statements selected from the pilot, 32-item epistemology Q study.

Fifteen students performed sorts after completing their first semester physics final during the fall 2006 semester. Instructions for performing the sort were offered both orally and in writing. Participants were instructed to initially sort the 44 statements into three piles: most like my view of learning, neutral, and most unlike my view of learning in this physics course. Participants then distributed the statements, each on a separate strip of paper, on the forced Gaussian distribution grid. Once participants were satisfied with their statement distribution, they recorded the statement numbers in the grid. Participants also completed a questionnaire regarding their age, class rank, sex, and course grade expected. The instructor later added the final course grade to this demographic information. For completing the sort, participants received a $10 gift certificate. The instructor sorted the same 44-item Q sample but with two different conditions of instruction: (1) What is your ideal student's view of learning in this physics course; (2) What is the typical student's view of learning in this physics course.

All Q-sort data were entered into and analyzed with PQ Method. Within Q methodology, the centroid method is recommended for extracting the factors because of the indeterminacy of its solution (McKeown & Thomas, 1988; Schmolck, 2002). The indeterminacy of the centroid solution allows the researcher to rotate the factors based upon theoretical considerations using hand rotation (Brown, 1986; Brown, 1980; Stephenson, 1955). Thus PQ Method's hand rotation option, via a graphical interface, is preferred especially in cases where it is important to ensure a specific participant is represented by a factor, such as a person with leadership role within the group (McKeown & Thomas, 1988). Based upon these recommendations, the researcher chose to perform a centroid extraction followed by hand rotation to ensure that the course instructor's views were represented by a factor. Ensuring that the instructor's "ideal" and "typical" views were each represented by a factor allowed the researcher to examine students' epistemological views relative to these instructor views. The pre-flagging algorithm was used to select those individuals most closely associated with the factors that emerged. Only the flagged individuals are used to create the representative Q sorts discussed in the Results section. These results of the Q analyses in addition to written responses by the sorters, related to the statements they chose to place at the –5 and +5 grid positions.

Results

Fifteen students and one instructor performed the Q sorts. All 15 of the students were male engineering technology majors. The average age of the student sorters was 21.5 years. Three factors emerged as displayed in Table 1. The largest factor, factor 1, represents 11 students and both the typical and ideal student sorts of the instructor, as indicated by bold loadings within the table. Of the two remaining factors, factor 2 was represented by three student sorters and factor 3 was represented by one sorter.

Table 1: Factor Loadings

Q sort no.	*ID*	*Factor 1*	*Factor 2*	*Factor 3*
1	18MConC	**61**	01	-06
2	19MFmetC	**83**	-14	-19
3	18MFconC	**73**	-33	33
4	19MFmetB	02	**30**	-05
5	18MFmetC	**63**	12	30
6	28MJmetF	20	**46**	39
7	24MFconC	**61**	-13	46
8	36MFmetA	**64**	-60	-06
9	22MJmetB	42	**-49**	-07
10	21MJsurD	40	10	**44**
11	19MSmetC	**67**	-27	-11
12	19MFmetB	**43**	22	-07
13	18MFeetC	**44**	-27	26
14	24MSsurD	**48**	44	-05
15	20MFconC	**57**	13	28
16	Ideal Student	**58**	-32	34
17	Typical Student	**53**	36	-28

Note: Loadings shown to two places, decimals omitted; those representing a factor indicated in bold.

Thus, the majority of students had a view similar to the instructor's view of an ideal student. In addition, the instructor's ideal student view and typical student view were represented by the same factor, factor 1. The normalized z-scores are produced for each factor and can be used to construct a representative Q sort for each factor. In the case of factor 1, Table 2 lists those statements receiving the highest positive z-scores (representing the most like my view) and highest negative z-scores (representing the least like my view) for factor 1. The resulting grid position is also reported. The statements most strongly associated with the factor 1 view include a need to work hard, learn from mistakes, and work with classmates. Factor 1 students' written comments also support these findings. Students on this factor received grades ranging from A through D. In addition, the written comments from a student receiving a C stressed that the sorting process enabled him to reflect on his learning efforts and helped him see what types of actions he could take to improve his learning in future classes. These words appear to be true since this student became one of the highest scoring students overall in the second semester of physics the next semester.

Table 2: Factor 1 High- and Low-ranking Statements

Item #	*Q sample Statement*	*z-score*	*Grid position*
8	Working with classmates inside and/or outside this class helps me learn.	2.006	5
7	In this class, if I can't understand something right away, I will keep on trying.	1.795	4
37	I enjoy solving problems.	1.657	4
40	I learn from the mistakes I make in this class.	1.517	3
25	Doing homework helps me learn in this class.	1.326	3
33	If I regularly come to class that should be enough to pass this class.	-1.234	-3
36	I would learn more in this class if I spent more time reading the textbook.	-1.237	-3
6	I have very little control over how much I learn in this course.	-1.515	-4
13	I often wonder how much my professor really knows.	-1.662	-4
4	I don't have to work hard to learn in this class.	-1.725	-5

The top five most like my view and least like my view statements for factor 2, shown in Table 3, indicated a view of learning that is different from factor 1. The factor 2 view included a number of statements about struggling to learn, needing to learn how to learn in this class, and an inability to apply course materials to real-world situations. Although this factor included two B students and the only F student, the view is one of struggling with the course and dislike of mathematical problem-solving.

Table 3: Factor 2 High- and Low-ranking Statements

Item #	*Q sample Statement*	*z-score*	*Grid position*
2	I need to learn how to study more effectively to succeed in this course.	2.259	5
35	I am struggling to learn in this class.	1.909	4
14	Sometimes I just have to accept answers from my professor even though I don't understand them.	1.787	4
5	I need to learn how to learn in this class.	1.753	3
9	In this class, learning something really well takes me a long time.	1.644	3
37	I enjoy solving problems.	-1.186	-3
19	Thinking about what this professor says is more important than memorizing what he/she says.	-1.337	-3
32	I only do as much work as necessary to pass this course.	-1.630	-4
24	I feel comfortable applying what I learned in this class to the real-world.	-1.664	-4
27	I like the exactness of math-type subjects.	-2.318	-5

Only one student is associated with the factor 3 view thus the representative sort is this student's Q sort. Because only one student is represented by this factor, tables of data are not included here. However, it is interesting to note that this student agreed that he was interested in learning the topics of the course yet also agreed that he would like to have problems on tests and quizzes be those that were previously solved in class. This student received a D in the course.

The study also revealed eight consensus statements, five with non-significant differences among the three factors at the .05 level and three statements, marked with an asterisk, non-significant at the .01 level (see Table 4). One of these statements with non-significance at the .01 level indicated agreement that students did not view reading the textbook as helpful for learning in this course. The views' consensus also included agreement that learning takes a long time and a relatively neutral view of physics websites as useful for learning in this physics course. Finally, students' written comments about the sorting process indicated that, for some, the sorting process helped them better reflect on how they learn and how to improve their learning even though statement 28, which is about reflecting on understanding in the course, fell into a neutral position for each factor and, thus, is listed as one of the eight consensus statements.

Table 4: Consensus Statements

No.	Statement	Factor 1 position	Factor 2 position	Factor 3 position
9	In this class, learning something really well takes me a long time.	3	3	1
16*	In this class, things are simpler than my professor would have me believe.	0	-2	0
21*	I reorganize the information from this course so it makes sense to me.	0	-2	-1
26*	Reading the textbook helps me learn in this class.	-3	-2	-3
28	I often think about how well I understand the topics in this course.	0	-1	-1
29	What I learn in this class will help me in other classes.	2	1	0
31	I would learn more in this class if I spent more time studying.	2	1	-1
43*	Using a website(s) helps me learn in this class.	-2	0	0

*All listed statements are non-significant at $p>0.01$, and those flagged with an * are also non-significant at $p>0.05$.*

Conclusions and Implications

The purpose of this study was to demonstrate that Q methodology offers an efficient way to reveal the multiple personal-epistemological views in a classroom. Q methodology is unique in that it allowed the researcher to examine each of the distinct personal epistemological views within this classroom. In addition, one student specifically commented on how the Q sorting process enabled him to be more reflective about his views of learning. Three personal epistemological views, represented by factors, were found using Q methodology. In addition, this study's use of Q methodology, allowed the researcher to examine how students' epistemological views compared to how their instructor perceived their views (both as ideal students and as typical students). It is interesting here to note that the instructor's ideal and typical student sorts are represented by the same factor, implying that the idea and typical student are not much different in her view.

This first perspective (factor) represented 73 percent of the students, with a range of course grades, as well as the instructor's ideal and typical student views. Thus the majority of students appear to have the view desired by the course instructor which includes striving for learning, collaborating with peers, and persistence. Unfortunately, this study did not include evaluating students' views of learning at the start of the course so no conclusions can be drawn regarding changes in students' personal epistemology.

Certainly the factor 2 view represents a different perspective of learning in this first-semester college physics class. Students represented by this factor appear to be struggling to learn in this class and feel that they need to understand how to improve their learning. Interestingly, two out of three students represented by this factor received B's for the course while the third received an F. Similarly, the D student represented by factor 3 indicated that he was genuinely interested in the topics of the course and learned from his mistakes. Thus, these different epistemological views do not appear to simply reflect students' earned course grades but these may not be representative of students' knowledge or learning. More valid and reliable measures of understanding or learning may be needed to investigate this finding further.

In addition to revealing three distinct views of learning within this first-semester physics class, consensus among these views was also determined via the use of Q methodology. The consensus regarding reading the textbook indicates a need to further examine how much, if at all, and how, students in this course utilize the textbook. This consensus is similar to the findings of Podolefsky (2006).

Thus, Q methodology offered a means of determining the multiple perspectives on learning and knowledge in a first semester physics class. Although the Q sample only contained 22 revised statements from the original Schommer (1990) survey, some comparisons can be made. Recall that Schommer found that the epistemology survey she created contained four factors or dimensions, opposed to one single view. Regression analyses were then used to investigate how well each of these dimensions predicted students' knowledge on specific tasks. Certainly, the Q results from this study could be used similarly, within regression models to predict some criterion such as a score on a conceptual evaluation such as the Force and Motion Conceptual Evaluation (Thornton & Sokoloff, 1998).

However, this Q investigation did not restrict students' epistemological views to four dimensions. Instead, Q allowed the researcher to see which students had similar personal epistemologies (revealed as factors) and how students' views compared to their instructor's view of their epistemology. It also allowed students to construct their own meaning of the statements and their relative positions on the sorting grid, regardless any perceived or determined dimension. Although Schommer's work enabled researchers to see that personal epistemology can be characterized by more than a single score on a Likert-survey instrument, this study shows that Q allows researchers to determine a more complex view of students' personal epistemologies through the creation of a representative sort for each view, determining of consensus among the views, and the revealing of distinguishing statements for each view. Thus, the results of this Q study further support McKeown's (2001) statement that Likert-scale surveys are not as powerful as Q methodology for determining perspectives and result in a loss of meaning. Future studies should use the perspectives generated through Q to investigate student learning or understanding in order to further support the strength of Q for investigating students' personal epistemologies.

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