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Learning in the Geoscience Classroom: Q-Methodology, Learning Styles, and Individual Preferences

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ABSTRACT

One of the challenges of traditional student learning, from an instructor's perspective, involves achieving an understanding of how students learn. Q-method is an effective approach to improve understanding of human subjectivity, and, as this research suggests, it is an appropriate tool to assist educators to better understand how students learn. In particular, Q-methodology provides the educator with a robust tool to assess student learning styles. This paper adapted an existing learning style instrument to a Q-method analysis in an introductory geographic information system class. The analysis resulted in three learning groups: lone pragmatist, explorer, and synergistic. These three learning groups are described. The paper concludes that the use of Q-method can deepen understanding of students' learning skills and improve instruction through more balanced and learner-focused curricular approaches. © *2013 National Association of Geoscience Teachers*. [DOI: 10.5408/12-301.1]

Key words: Q-method, education, student learning, learning styles, learner focused

INTRODUCTION

It is widely acknowledged that students learn in different ways (Dweck and Bernpechat, 1983; diSessa, 1985; Jonassen and Grabowski, 1993; Gardner, 1999; Lynn, 2009). Researchers have suggested that learning is a progressive developmental process based on educational experiences and personal traits (Perry, 1970; Entwistle and Peterson, 2004). Entwistle and Peterson (2004) stated, "What students believe about learning overlaps with what they hope to achieve from being in higher education" (p. 412). Quantitative and qualitative methods that enable educators to understand how students learn and view learning are valuable because they may allow educators to more positively influence student learning. One area of study, known as learning styles, has focused on understanding and characterizing individual preferences for acquiring knowledge. Most existing student learning styles instruments are quantitatively based and group students into predefined categories (Vermunt and Verloop, 1999; Entwistle, 2005; Felder and Spurlin, 2005; Hendry et al., 2005). The use of predetermined categories has positive and negative attributes. From a positive perspective, the classifications have been validated, and basic assumptions can be made. One of the major criticisms of existing tools is the inability to provide depth to the educator and student understanding of learning skills (Cerbin, 2009). To this end, Q-method may provide educators with additional insights about how students learn. Q-method is a research methodology that has been used for many years to help researchers understand the subjectivity of a given sample.

The purpose of this paper is to demonstrate how Q-method, as a tool, can be used to provide educators better understanding of how students learn. This is done by applying Q-method analysis derived from a learning styles instrument to students in an introductory geographic information system (GIS) class. Q-method has been applied to various disciplines since its invention in the 1930s. Its application has diversified significantly from its original development, principally in the areas of psychology, politics, health, management, and environmental studies. Yet, Q-method has had limited exposure in the student learning styles and strategies literature.

Q-METHOD

Q-method merges qualitative and quantitative methodologies, allowing a view of the data from a subjective perspective. Brown (1980) states, "Q is an intensive form of analysis and always works with small numbers of subjects. . . .the patterns that Q-methodologists find in some small group of subjects can be expected to reflect or intimate the structure existing in some larger population of subjects" (pp. 66–67). Q-method is based on the assumption that subjectivity can and will be expressed by a person's own behavior as reported through their ranking of statements (Wigger and Mrtek, 1994). Operationally, Q-method asks subjects to systematically sort a set of statements based on how strongly they agree (positive on the Q-sort board) or disagree with each statement (negative on the Q-sort board; Brewer et al., 2000; Robbins and Krueger, 2000; Jacobson and Aaltio-Marjosola, 2001; McLean et al., 2005). It requires that participants evaluate each statement in relation to every other statement and reflects the person's worldview of the topic (Brewer et al., 2000). This allows Q-method to produce an individual's comprehensive attitude, while surveys usually only produce separate pieces of information that may contribute to a person's attitude (Brewer et al., 2000).

The completed rankings, or Q-sorts, are correlated and factor analyzed to identify specific respondent groups that

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ranked the statements or elements in similar ways (Brewer et al., 2000). Outputs of Q-method are called Q-factors, and they represent different states of subjectivity (Brown, 1991). The Q-factors are generalizations of attitudes held by the respondents that define a given factor. Therefore, Q-factors permit direct comparisons between them irrespective of the number of people who subscribe to them (McKeown and Thomas, 1988). This enables researchers to categorize respondents who share attitudes and perspectives (Brewer et al., 2000). Finally, meanings discovered via Q-method are not found solely in the categorical thoughts of the observer, but also in the reflections of a person as he or she sorts the statements in the context of a singular situation (Brown, 1991).

Q-Sample and P-Sample

Q-methodology requires the development of a Q-sample and a P-sample. A Q-sample, or the statements or elements to be evaluated, are commonly derived from previous research. For example, McLean et al. (2005), studied competencies of public recreation and park chief executive officers (CEOs). In their study, they derived 82 competencies from Hurd and McLean's (2004) research on CEO competencies. These 82 competencies constituted the study's Q-sample. The P-sample, or person sample, is the number of people ranking the competencies. So, the P-sample for McLean et al. (2005) was 13, where there were 13 CEOs ranking 82 competencies.

Q-method and R factor analyses are both complex forms of regression analysis and are used to reveal similarities in data (Clark, 2002). However, Q-method differs from R factor analysis. For example, R factor reduces data into traits such as ethnic background, whereas Q-method identifies common patterns of self-referenced traits. In short, Q-method allows respondents to model their viewpoints on a matter of subjective importance (McKeown and Thomas, 1988).

LEARNING STYLES

The literature on learning styles has matured, and the number of available inventories has grown over the last 30 y. There is general agreement among learning style researchers that students rely on different learning styles to succeed, and the importance of recognizing different learning styles as a resource to improve pedagogy is well documented (e.g., Kolb, 1985; Felder and Silverman, 1988; Bransford et al., 1989; Felder, 1993; Vermunt, 1994; Felder and Brent, 2001, 2005; Cassidy, 2004; Hall et al., 2008). The inventories have also evolved, and a number now link student learning styles and study strategies as related cogent variables.

Inventories come from different conceptual foundations and reflect differing backgrounds of their respective developers. Indeed, there are many different definitions, concepts, models, and interpretations of student learning in the literature (Cassidy, 2004). However, there are several unifying themes in student learning style research literature. For example, several researchers have developed learning style measures based on different theoretical approaches. Cassidy (2004) provided information regarding some of the early learning styles instruments that emerged over the previous 25 y. Curry (1983, 1987) proposed an onion-style metaphor, suggesting the presence of inner and outer layers as a way of explaining theoretical constructs. Riding and Cheema (1991) used over 30 categories to describe a variety of learning styles (Cassidy, 2004) and ultimately classified the measures into a wholist–analytic or a verbalizer–imager framework, based on how people process information: whether inductively as a whole (wholist) or deductively in separate parts (analytic). Felder and Silverman (1988) proposed a model of learning styles called an Index of Learning Styles (ILS), a questionnaire consisting of four scales (sensing–intuitive, visual–verbal, active–reflective, and sequential–global), each with 11 dichotomous, paired items. Felder and Silverman were influenced by various aptitude models, including Kolb's learning processes of active experimentation versus reflective observation, Jung's model of psychological types, and the Myers–Briggs Type Indicator (Litzinger et al., 2007).

Rationale for Using Q-Method to Deepen Instructor Understanding

The ability of teachers to understand different learning styles and their potential influence on student learning may enhance teachers' understanding of their students and allow them to more effectively structure their courses and teaching practices (Felder and Silverman, 1988). To this end, we proposed that Q-method may be an appropriate research tool to differentiate within learning styles, revealing a deeper understanding of student learning styles and perceptions. Indeed, it is our belief that Q-method can deepen instructor understanding of learning styles and provide the instructor with clues related to student learning within the different categories. Two recent studies used Q-method to analyze learning styles. Driver et al. (2008) used Q-method to discover learning identities in an undergraduate political science course. The authors used 41 statements and discovered five learning identities. Liu (2008) found three separate learning styles for e-learners. Given these studies and others cited earlier herein, we feel that Q-method may be an appropriate tool that allows educators to better understand how their students learn.

One of the advantages of Q-method allows the researcher, or in this case, also the educator, to look at P-samples as small as an n of one. The small n of most classes significantly reduces the validity of traditional factor analysis and other statistical tools. The power comes from being able to merge quantitative and qualitative data to better understand learner attitudes and perspectives, an inherently subjective endeavor, allowing instructors to gain greater depth of understanding by mixing Q-method with qualitative research techniques. The learning styles inventory gives us clues about learning and study strategies, and Q-method narrows that focus, giving depth to the instructor's knowledge. A learning styles inventory provides a useful starting point for increasing effectiveness of instructors, but with Q-method, the potential effectiveness can be extended and deepened.

Since Q is essentially R on its side from a mathematical point of view (Danielson, 2009), the n in Q is not the participants but rather the Q-statements. Thus, determining a good sample is very important. This posed unique challenges with this study. Most significantly, there is the fact that we were converting R-statements to Q-statements. Aside from being short, easy to read and understand, stand-alone statements, a good Q-statement does not share any of the qualities of a good survey R-

statement. Webler et al. (2009, pp. 8–9) offer a very insightful description of the differences between the two. In short, four criteria determine effective Q-statements: (1) The statements should contain excess meaning (suggesting they can be interpreted in different ways by different groups); (2) the Q-statements must adequately represent the concourse; (3) Q-statements are expected to be interpreted in the context of all other Q-statements; and (4) Q-statements should be short stand-alone sentences that are easy to read and understand.

Good Q-statements represent the concourse from which the study is drawn. The term concourse is linked to the idea of communicability, where "no one knows in advance what someone else is going to say or suggest, or how what one person says is going to impact on what others say or think" (Brown et al., 1998, p. 608). They go on to state, "Pierce's (1955) 'Law of the Mind'" means "ideas spread and affect other ideas and eventually combine into a system, or schema. Concourse is therefore at the foundation of a society and provides lubrication for all its parts, and constitutes the very stuff of which decisions are made and problems solved" (p. 608). For our purposes, Felder and Soloman's ILS[1] was used to glean the concourse and provided a series of statements in R form for his use. Our task was to convert, or maybe more appropriately "revert," those statements to a Q-form. We selected Soloman and Felder as our concourse since it is a well-documented assessment (Zywno, 2003; Litzinger et al., 2007; Felder and Soloman, 2012). It also had the benefit of a manageable number of items: 88 (4 scales of 11 paired statements), compared to other models such as Vermunt's (1998) 120 item instrument, for example, which is far too large for a Q-sort. There is a limit to the number of questions a participant can effectively manage in a Q-sort. Soloman and Felder's ILS offered the additional benefit of its use of four scales. This differs from a model such as Vermunt's model, which has specific categories. We expected the emergence of groups from the Q-sort that would allow us to drill beyond the descriptive categories of Felder and Soloman's index.

However, Soloman and Felder relied on dichotomous paired statements from which participants would select the one most like them. This posed some problems in terms of Q-statement criteria (1) and (4). A good Q-statement should not be dichotomous. Furthermore, while 88 items were more manageable than 120, it still was too large for a Q-sort. The authors individually took the 44 base statements and the dichotomous responses and used the Q-statement criteria to reconstruct each statement. The resulting questions were compared and revised, reviewed, and finally adopted according to their ability to meet the Q-statement criteria. For example, Soloman and Felder's statement, "In a book with lots of pictures and charts, I am more likely to (a) look over the pictures and charts carefully, or (b) focus on the written text," was rewritten to state, "In a book with lots of pictures and charts, I am likely to focus on the written text." The final statements, as a whole, best represented the concourse.

[1] URL to the Soloman-Felder Learning Styles Questionnaire (http://www.engr.ncsu.edu/learningstyles/ilsweb.html).

METHODOLOGY

The Q-samples were generated as described above. The P-sample in this study included students selected from an introductory GIS class at the 200 level and asked to rank each of the items in the Q-sample. Students were predominantly geography majors at a sophomore level participating in a laboratory-based class. Eighteen students comprised the P-sample for this study. These students completed the Q-sort and were included in the analysis. The Q-sort looked like a standard distribution using the 44 statements (see Fig. 1). The Q-sort requires that participants evaluate each statement in relation to every other statement and reflects the person's worldview of the topic (Brewer et al., 2000). Traditional quantitative measures look for objective measures that can be compared across subjects, such as intelligence, athletic ability, knowledge, and the like. The Q-methodology, by contrast, deals with states of mind where the way in which the individual respondent orders stimuli is more important than the extent to which the respondent compares to others. It can be used to study a single individual, as is commonly done in psychology, education, and sociology, or to examine collections of individuals, as is done in this article.

After the Q-samples were sorted, the Q-sorts were correlated and factor analyzed using the principal components method. The factors were then rotated using varimax criteria to discover factors with significant loadings. Each of the factors represents a theoretical template that is derived from the placement of the statements or elements. Respondents who load significantly on a factor have similar views of the topic being investigated (Brewer et al., 2000). The statements that most reflected each factor were reviewed, and the three factors were labeled "loan pragmatist," "explorer," and "synergist." In the following discussion, numbers in parentheses [for example: (1) or (1, 8)] represent a single (1) or multiple (1, 8) Q-statements. A complete list of Q-statements, with their corresponding identifying numbers, appears in Appendix A, and they are also organized by factor in Tables I, II, and III.

RESULTS

Lone Pragmatist

The term "lone pragmatist" was selected to represent students in factor 1. Individuals in this factor are realistic and prefer not to be involved in cooperative or group learning (16). Indeed, they don't consider themselves to be outgoing (25), and they seldom get to know students in their class (18). When working on a new project, they prefer to just jump right in and start working on it rather than sit around planning it first (26), but they do not look for new ways of doing the same task (39). They prefer that instructors provide lesson material in a clear manner (34), and they don't like learning about abstract theories (31). These individuals seem to be very practical learners who are not comfortable learning new things with other people (33, 16). This might suggest a limited attention span for this group, as well as reduced creativity and problem-solving skills. They like the idea of having information provided to them. On the surface, they do not appear highly motivated, and when extended to pedagogical interpretations, these students may not be good candidates for cooperative learning approaches.

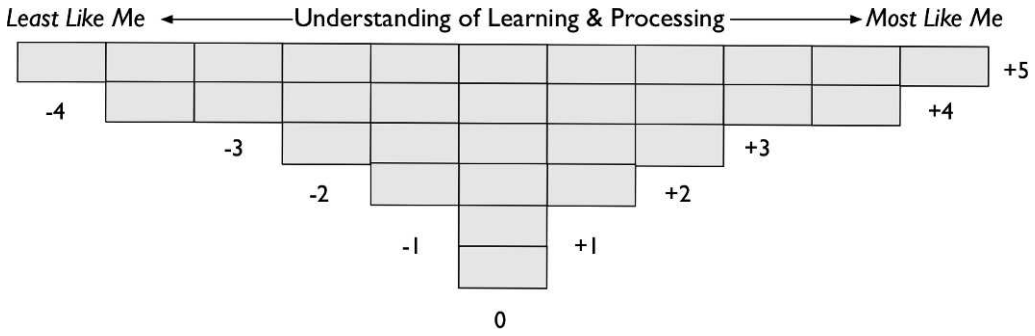

FIGURE 1: Q-sort board.

Explorer

These individuals learn better when talking about new material with other students (14, 3), although they are somewhat ambivalent about group study (16). They enjoy seeking new ways of doing the same task (39)—significantly more than the other two groups. Explorers tend to be more visual (29, 19, 11) and appreciate outlines of lectures and lessons (10) more than the other two groups; however, neither of these was a dominant trait by any means, with both ranking neutral. With respect to concrete/sensory versus abstract/intuitive orientation, explorers appear to be more complex than lone pragmatists in their orientation regarding concrete/sensory versus abstract/intuitive. On one hand, they prefer courses with a lot of concepts and theories (34), but on the other hand, they are ambivalent towards (if they were a teacher) teaching a course dealing with abstract theories (31); what's more, they are interested in the practical application of those theories (30). They also do not value imagination over sensibility (44). Individuals in this factor seemed to value learning new things and exploring multiple ways to learn. Individuals are significantly more holistic in both their encoding (6) and especially output styles (4).

Synergist

Synergistic learners, more than the other two groups, tend to encode and recall more verbally than visually (40, 23). When getting directions to someplace new, they prefer written directions rather than a map (13). They like group study (16) and enjoy "brainstorming" (21) as part of the group learning process. They see themselves as detail oriented (37) and tend to be more abstract/intuitive than the other two when they read books for entertainment, preferring books with clever prose to an engaging story (32); however, they do not prefer learning concepts to facts (31, 34, 35). In fact, with respect to this, they are the least conceptual. They do not like courses that emphasize concepts and theories. To learn something new, they have to try it out first (12); however, they do not like looking for new ways to do the same task (39). These types of learners tend to want to see the whole picture so that they can better understand the details of a problem or project (28). In summary, synergists like to integrate others into the learning process and to link their learning to the bigger picture.

Group Similarities

There were several similarities that pervaded the three factors (Table IV). All three groups see pictures as opposed to words when they think about what they did yesterday (1), suggesting they are more visual. They also prefer to get information from pictures, graphs, maps, and diagrams (5, 9). It might be hypothesized that these students, members of the millennial generation, are beginning to exhibit a visual and graphic orientation that has been suggested as representative of their generation. The groups also learn things more easily when they have to "do" something to learn about it—rather than just thinking about it (36, 17). To this end, the groups also agreed that it is easier to remember something they have done rather than something they have just thought about (41). Finally, the three groups all learn best when instructors provide lesson material in a clear sequence of steps. The similarities suggest starting points for instructors as they prepare their classes and choose strategies that will initially engage students and then divert to other learning opportunities based on student learning preferences.

DISCUSSION

Two conclusions can be drawn from the results of this study. First, Q-method does provide a viable methodology with which to explore individual learning styles. The results of the study produced three clear groups, each with specified preferences and aversions. It also identified preferences shared among all the groups. The benefit here is the collectivizing of the results. For its advantages, the Soloman-Felder ILS may be very useful in helping students recognize their own predilections. This, however, is its weakness as well. From an instructor point of view, individual models could be difficult to extrapolate to course-wide preferences. The goal is not to design individualized leaning strategies. That would be impracticable in most settings. Rather, learning style models can be used to better understand the class as a whole. To this end, Q-method allows us to take the very useful concourse produced by the Soloman-Felder ILS to create a clearer picture of the collective preferences within a course or set of courses. In this study, the instructor can focus on the commonalities, providing opportunities across learning styles and then develop opportunities for students to use individual strengths to deepen their learning.

Second, Q-method provides a tool to more deeply understand existing models such as the Soloman-Felder ILS. To begin with, the reliability of the Soloman-Felder ILS has been verified (Litzinger et al., 2007). That does not dismiss the pursuit of a deeper understanding of the processes

TABLE I: Lone pragmatist.[1]

ST	LP	EX	SY	Statement
18	4	0	−2	I rarely get to know many other students in my class.
33	3	2	1	I consider myself to be realistic.
42	3	0	0	I have to force myself to recheck my work for details because I think this is very tedious.
26	2	−1	−1	When working on a project, I prefer to just jump in and get it going rather than sit around and plan it.
28	1	−4	−1	When solving math problems, I often can jump to the solution but have difficulty describing the steps of how I got there.
7	0	−1	−2	In a book with lots of pictures and charts, I am likely to focus on the written text.
2	0	1	1	When solving problems in a group, I am likely to think of the solution in term of possible consequences or applications.
43	0	2	3	I need to understand the whole thing before I can see how the parts fit.
24	−1	1	2	I prefer to fully understand a homework problem before I can start working on it.
34	−2	2	−4	I prefer courses that emphasize concepts and theories.
39	−2	2	−1	I am always looking for new ways of doing the same task.
16	−2	−1	1	I prefer to study in a group.
25	−3	0	0	I am more likely to be considered outgoing.
31	−4	−1	−5	If I were a teacher, I would prefer to teach a course that deals with abstract theories.

[1]ST = statement; LP = lone pragmatist; EX = explorer; SY = synergist.

behind the ILS's scales. As demonstrated by this study, Q-method provides a mechanism to flesh out some of these deeper processes. For example, the Soloman-Felder ILS recognizes both input and output styles among their questions of the visual–verbal dichotomy (Litzinger et al., 2007), and yet the final output merely presents the subject's relative preference towards visual or verbal along a single scale. One of the interesting findings from this data set was emergence of differences between output and input styles. For example, the explorer, like all the other groups, prefers instructors to present material sequentially (input) yet prefers to write different parts of the paper and then bring them together (output). This may indicate a difference between input preference and/or a difference between visual (how most outlines may be perceived) and verbal (how writing is produced).

Furthermore, while Soloman-Felder recognizes that a scale preference is not an either–or proposition, results tend to be consolidated into a single results output. Take for instance the sensing–intuitive dichotomy. According to

TABLE II: Explorer.[1]

ST	LP	EX	SY	Statement
14	2	5	4	I learn better if I can talk about the new material with someone else.
6	1	4	0	When considering a body of information, I am more likely to focus on the big picture rather than the details.
4	−5	3	−2	When writing a paper, I am more likely to work on (think about or write) different parts of the paper and then order them.
39	−2	2	−1	I am always looking for new ways of doing the same task.
34	−2	2	−4	I prefer courses that emphasize concepts and theories.
18	4	0	−2	I rarely get to know many other students in my class.
10	2	0	2	It's more difficult for me to understand a lecture if the teacher does not provide an outline.
11	−3	−1	−3	I remember better what I hear than what I see.
31	−4	−1	−5	If I were a teacher, I would prefer to teach a course that deals with abstract theories.
16	−2	−1	1	I prefer to study in a group.
19	1	−2	1	When someone is showing me data, I prefer text summarizing the results.
3	0	−3	−1	When I am learning something new, it helps me more to think about it than to talk about it.
30	0	−3	−1	I am not very interested by the practical application of theoretical concepts.
44	0	−4	−1	I consider it higher praise to call someone imaginative rather than sensible.
28	1	−4	−1	When solving math problems, I often can jump to the solution but have difficulty describing the steps of how I got there.
29	−2	−5	−1	I tend to picture places I have been with difficulty and without much detail.

[1]ST = statement; LP = lone pragmatist; EX = explorer; SY = synergist.

TABLE III: Synergist.[1]

ST	LP	EX	SY	Statement
12	3	3	5	To understand something new, I need to try it out first.
37	1	1	4	I am likely to be considered detail oriented.
13	−1	0	2	When I get directions to a new place, I prefer written instructions to a map.
16	−2	−1	1	I prefer to study in a group.
23	−1	0	1	When I meet people at a party, I am more likely to remember what they said about themselves than what they look like.
40	−1	−2	0	To get information, I would rather read a description than look at a chart.
8	2	2	0	I tend to understand the overall structure of a subject but may be fuzzy about details.
32	−4	−3	0	When reading for enjoyment, I prefer cleverly written prose to an engaging story.
39	−2	2	−1	I am always looking for new ways of doing the same task.
28	1	−4	−1	When solving math problems, I often can jump to the solution but have difficulty describing the steps of how I got there.
18	4	0	−2	I rarely get to know many other students in my class.
35	0	−1	−2	I find it easier to learn concepts than facts.
34	−2	2	−4	I prefer courses that emphasize concepts and theories.
31	−4	−1	−5	If I were a teacher, I would prefer to teach a course that deals with abstract theories.

[1]ST = statement; LP = lone pragmatist; EX = explorer; SY = synergist.

the ILS, sensing individuals have a preference for concrete and real-world application of learning; intuitive individuals prefer abstract concepts and theory (Litzinger et al., 2007). The ILS places an individual somewhere along a continuum depending on his or her responses. Use of Q-method more fully illustrates ways in which groups of individuals differ within the spectrum. Take the explorer as an example once again. These individuals had strong preferences towards concepts and theories and do not prefer imagination over sensibility. One might expect them then to score reasonably high on the sensing side of the scale. However, this would dismiss the fact that they are still interested in the practical application of such theories. Given the fervor of this division among some faculty within many of our universities and even departments, this is no small nuance. So how might we apply this to the classroom? The following section provides some suggestions for the application of these findings.

Significance of Results

In practice, it would be difficult to cater different teaching styles to meet the needs of each of these three groups. We propose adopting a balanced approach in which teachers create course plans to address the variety of learning styles present in their class (Litzinger et al., 2007). Vermunt and Verloop (1999) discuss the friction that exists when teaching strategies and learning strategies are not compatible. Some friction may be constructive, such as when it compels students to stretch their existing strategies and skills. Other friction may be destructive, i.e., when existing or potential thinking and learning skills are not called upon or developed. Like students, teachers tend to gravitate to the styles with which they are most comfortable. Use of learning styles models as proposed by Litzinger et al. (2007) may help teachers avoid falling into such pedagogical traps. One example of destructive friction is the tendency instructors frequently have to take over as many learning and thinking activities as possible, for instance, by providing detailed

TABLE IV: Similarities.[1]

ST	LP	EX	SY	Statement
1	−2	−2	−3	When I think about what I did yesterday, my mind sees words as opposed to pictures.
5	2	1	1	I prefer to get new information from pictures, graphs, maps, and diagrams.
9	1	0	2	Teachers who put a lot of diagrams on the board make it easier for me to learn.
12	3	3	5	To understand something new, I need to try it out first.
17	4	4	3	I find learning occurs more easily when I have to do something rather than just think about it.
21	1	1	2	When I have a group project, I prefer to brainstorm as a group first, so everyone can contribute.
27	1	1	1	For entertainment, I prefer reading a book.
36	−3	−2	−3	It's easier to remember something I have thought a lot about than something I have done.
38	−1	0	0	I prefer to learn everything I can about a new subject before moving on to related subjects.
41	5	3	3	I like instructors to provide lesson material in a clear sequence of steps.

[1]ST = statement; LP = lone pragmatist; EX = explorer; SY = synergist.

outlines (Vermunt and Verloop, 1999). Vermunt and Verloop suggest moving from teacher regulation to student regulation in what they refer to as process learning. They state, "In terms of development in student' learning styles, process-oriented teaching aims at stimulating the development of meaning and application-directed learning styles and discouraging undirected and reproduction-directed ways of learning. The main tasks for teachers in this view are initiating, supporting and influencing the thinking processes that students use to learn (Simons, 1993)" (Vermunt and Verloop, 1999, p. 274). Rather than randomly throwing various teaching approaches up against the classroom in hopes that something sticks, we argue that time is better spent understanding the specific styles within the class. In this way, teachers may more effectively target positive frictions to help students stretch as well as reinforcing styles that predominate. As demonstrated in this study, Q-methodology offers an effective mechanism by which to accomplish this. In this way, instructors can think of using learning styles as a way of helping students gain satisfaction from learning and thus develop life-long skills by better understanding their own learning processes and preferences.

The power that Q-method provides an instructor in designing and delivering effective learning experiences can occur in any classroom. The GIS classroom provided an excellent laboratory to demonstrate Q-method. Application of this model could be effectively applied elsewhere. Herein lies the strength of the Q-method adaptation of the Soloman-Felder methodology: its adaptive capacity to multiple teaching and learning situations. As stated, the instructor can more fully understand ways in which groups of individuals differ within the classroom spectrum. Regardless of the setting, be it fieldwork, laboratory, or lecture, and regardless of the discipline, Q-method provides the opportunity to increase instructor understanding of learning opportunities within the classroom.

In the case of the GIS course presented in this study, the instructor can provide ways for students to comprehend course material visually with graphs and diagrams. Realistic cases and scenarios could take advantage of learning-by-doing instructional strategies to develop ill-defined problem-solving skills. That is not to say that verbal or reflective learning activities should be ignored. Rather, the application of such activities might be incorporated in a way to carefully expand student skill sets. At the same time, a balanced heterogeneity of learning activities should be incorporated to cater to the different learning styles. For example, while group projects might be appropriate for many of the learning-by-doing cases mentioned above, room could be also made for projects that addressed the learning styles of lone pragmatists. Such activities could be conducted so as to benefit some of the more cooperative learning–oriented students to stretch their ability to develop self-monitoring and other cognitive skills useful for learning on their own.

CONCLUSION

The results suggest that the use of Q-method is an appropriate tool to improve faculty understanding of how students learn. In particular, when combined with an existing measure of learning and study styles, the addition of Q-method could enable educators to deepen their own understanding of the ways that students perceive concepts, how they study, and how they learn. We advance the proposition that Q-method provides an ever greater flexibility and understanding of students in a specific class. It allows the researcher to reorder the questions in a way that provides additional clues about students' learning styles. Q-method provides the instructor the opportunity to cross scale boundaries, creating a richer picture of students. Where Litzinger et al. (2007) argue, "Once a model has been chosen to serve as a basis for instructional design, the instructor's goal should be to make sure that instruction sometimes addresses each learning style preference defined by the model" (p. 310), we offer the extension of such a thought through the use of Q-method to extend and deepen instructor understanding of how students learn. The end result is a class that strengthens opportunities for learning by taking advantage of student learning styles and balancing against single teaching approaches.

This paper has described the basics of Q-method, proposed that Q-method may be an appropriate tool to better understand student learning in courses, and described a study that used Q-method to determine three different learning groups in an introductory GIS course. We feel that Q-method has tremendous potential to help teachers better understand how students learn. This understanding will enable teachers to better instruct their students.

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APPENDIX A: Q-statements.

No.	Statement
1	When I think about what I did yesterday, my mind sees words as opposed to pictures.
2	When solving problems in a group, I am likely to think of the solution in terms of possible consequences or applications.
3	When I am learning something new, it helps me more to think about it than to talk about it.
4	When writing a paper, I am more likely to work on (think about or write) different parts of the paper and then order them.
5	I prefer to get new information from pictures, graphs, maps, and diagrams.
6	When considering a body of information, I am more likely to focus on the big picture rather than the details.
7	In a book with lots of pictures and charts, I am likely to focus on the written text.
8	I tend to understand the overall structure of a subject but may be fuzzy about details.
9	Teachers who put a lot of diagrams on the board make it easier for me to learn.
10	It's more difficult for me to understand a lecture if the teacher does not provide an outline.
11	I remember better what I hear than what I see.
12	To understand something new, I need to try it out first.
13	When I get directions to a new place, I prefer written instructions to a map.
14	I learn better if I can talk about the new material with someone else.
15	When I see a diagram or sketch in class, I am likely to remember what the instructor said before I remember the picture.
16	I prefer to study in a study group.
17	I find learning occurs more easily when I have to do something rather than just think about it.
18	I rarely get to know many other students in my class.
19	When someone is showing me data, I prefer text summarizing the results.
20	In reading nonfiction, I prefer something that gives me new ideas to think about than teaches me new facts or skills
21	When I have a group project, I prefer to brainstorm as a group first, so everyone can contribute.
22	In study groups working on difficult material, I tend to hold back and let others do the talking.
23	When I meet people at a party, I am more likely to remember what they said about themselves than what they look like.
24	I prefer to fully understand a homework problem before I can start working on it.
25	I am more likely to be considered outgoing.
26	When working on a project, I prefer to just jump in and get it going rather than sit around and plan it.
27	For entertainment, I prefer reading a book
28	When solving math problems, I often can jump to the solution but have difficulty describing the steps of how I got there.
29	I tend to picture places I have been with difficulty and without much detail.
30	I am not very interested by the practical application of theoretical concepts.
31	If I were a teacher, I would prefer to teach a course that deals with abstract theories.
32	When reading for enjoyment, I prefer cleverly written prose to an engaging story.
33	I consider myself to be realistic.
34	I prefer courses that emphasize concepts and theories
35	I find it easier to learn concepts than facts.
36	It's easier to remember something I have thought a lot about than something I have done.
37	I am likely to be considered detail oriented.
38	I prefer to learn everything I can about a new subject before moving on to related subjects.
39	I am always looking for new ways of doing the same task.
40	To get information, I would rather read a description than look at a chart.
41	I like instructors to provide lesson material in a clear sequence of steps.
42	I have to force myself to recheck my work for details because I think this is very tedious.
43	I need to understand the whole thing before I can see how the parts fit.
44	I consider it higher praise to call someone imaginative rather than sensible.