# The Use of Triangulation Methods in Qualitative Educational Research

*Triangulation involves the careful reviewing of data collected through different methods in order to achieve a more accurate and valid estimate of qualitative results for a particular construct. This paper describes how we used three qualitative methods of data collection to study attitudes of students toward graphing, hands-on activities, and cooperative grouping techniques using the triangulation method.*

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The significance of qualitative research comes from the role it plays in investigating the reasons and processes leading to certain results. Qualitative research has been described as work done to understand "meaning that is socially constructed by individuals in interaction with their world. The world, or reality, is not the fixed, single, agreed-upon, or measurable phenomenon that it is assumed to be in positivist, quantitative research" (Merriam 2002). Data-collection methods of qualitative research commonly include field notes, student journals or documents, surveys, and interviews. Although large volumes of data may be collected using qualitative methodologies, drawing conclusions from a wide range of information often becomes a challenging task. This was our case when we collected data to monitor attitudes of students toward our general chemistry class format. These data included 55 sets of interviews, 116 sets of survey responses, 90 journal entries, and 38 field note entries. We were interested in finding ways to:

- discern if different qualitative data-collection methods would expose different meaningful issues regarding attitudes of students toward different teaching techniques,
- effectively monitor attitudes toward both objective (graphing activities) and subjective constructs (teaching techniques), and
- validate qualitative data by comparing interpretations of results from different data-collection methods.

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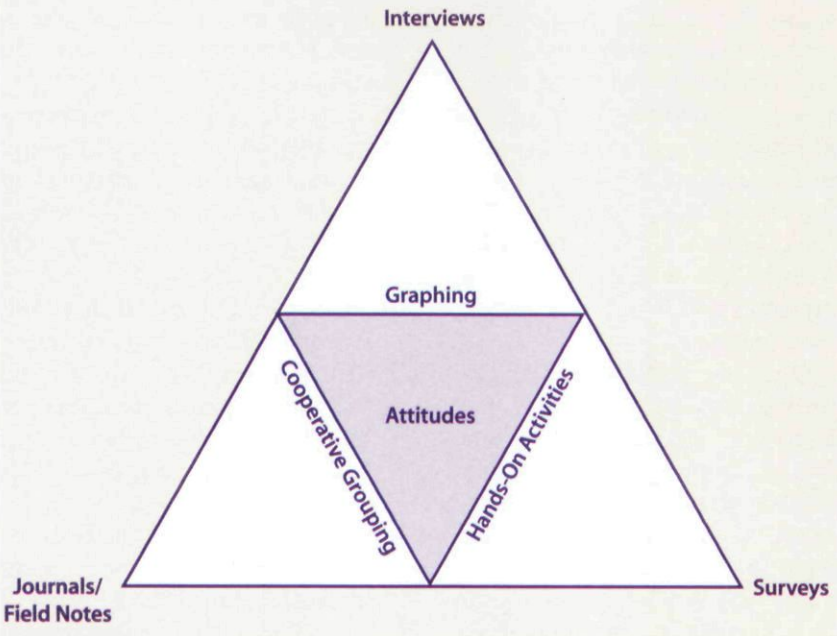
**FIGURE 1**

**Triangulated design for data collection**



Our investigative interests in assessment methods led us to the use of triangulation methods. Triangulation compares information to determine corroboration; in other words, it is a process of qualitative cross-validation (Wiersma 2000). Preferably, each method would measure the same construct while having a different error type inherent in that method. The deficiencies of each method would then average out, leaving a true estimate of a single result (Brinberg and Kidder 1982). Therefore, triangulation yields a more accurate and valid estimate of a result when each method of measurement actually converges on the same answer (Mark and Shotland 1987). However, complete convergence may not always occur in qualitative data. The result then becomes a range of possible estimates that includes the actual answer. The defining of the range is known as *bracketing* (Mark and Shotland 1987).

This article presents how we used the triangulation method to monitor change in attitudes of students toward cooperative grouping, hands-on activities, and graphing activities over the course of a semester. The triangulation scheme used data collected via three different qualitative research methods (interviews, surveys, and reflective journals or field notes). A schematic representation of our triangulation design is shown in Figure 1. Each vertex of the triangle produces results that are compared and weighed against the results of the other methods.

## Instructional setting

Data were collected during a second semester general chemistry course taught in a format designed to foster cooperative grouping and hands-on activities known as cAcL2, or concept Advancement through chemistry Lab-Lecture, which is a dissemination project of SCALE-UP, Student-Centered Activities for Large Enrollment Undergraduate Programs (Beichner et al. 2005; Oliver-Hoyo and Allen 2004, 2005; Handelsman et al. 2004). This format is ideal for the collection of these data because it emphasizes the teaching and learning techniques represented in our triangulation scheme. For example, students worked in groups of three that were formed according to cooperative grouping guidelines (Felder and Brent 1994) and class time was driven by hands-on activities with mini-lectures of 15–20 minutes interjected into the sequence of activities. Graphing was introduced when laptops were used to collect data using probes. The data were then used to construct graphs and interpret results. Even though we did not focus on the individual assessment of these teaching techniques, it is important to note that the attitudinal data were collected from a setting that promoted these techniques, therefore providing valuable data to be used in our triangulation method.

## Data collection

For the interview process, a random stratified sampling procedure was used to assign every student to one of three one-on-one interviews conducted during the semester. Approximately 18 students were assigned to each interview. In order to achieve samples that were representative of the class, the samples were stratified based on major, gender, and ethnicity. For instance, the student population in this course consisted of 51% physical science and engineering majors, therefore, 8 to 10 students out of the 18 randomly chosen to participate in a particular interview had to be physical science majors. The selections were then evaluated based on gender and ethnicity requirements for the sample, making the three interview samples as similar as possible. Students were required to attend these interviews and received three extra-credit points on an exam grade in return for their participation. A total of 40 people out of the final enrollment of 45 participated in an interview and 15 of those students participated in two interviews. The same interviewer conducted all interviews. In addition to these one-on-one interviews (interviews 2, 3, and 4), all students participated in a general interview (interview 1) conducted during class where students answered questions and three instructors walked around tables to answer questions and guide the interview process. These interviews were conducted during the second week of classes (interview 1), second and third month into the semester (interviews 2 and 3, respectively), and during the final two weeks of classes (interview 4). Therefore, we were able to monitor changes as the semester progressed.

Survey data included a standard departmental end-of-semester survey in addition to pre- and postsurveys developed specifically for the course. Students also made entries into reflective journals on a regular basis, responding to a wide variety of questions. The journal entries relevant to the triangulation study were obtained approximately halfway through the semester. Graphical data came from homework, survey questions, and the interview process. Data on attitudes toward cooperative grouping and hands-on activities were collected via interviews, journals, and surveys. For the attitudes towards graphical skills, field notes were used instead of journal entries. The field notes were collected while observing student behavior as they graphed certain data during segments of interviews 3 and 4. Behavioral patterns were identified and occurrences of these patterns tabulated.

## Results

Results are grouped by the construct being measured and tabulated by method of data collection.

### I. Cooperative grouping (Tables 1–3)

In monitoring attitudes toward cooperative grouping, interview and journal entries results suggest that student attitudes became more posi-

tive over the course of the semester. However, no conclusions can be drawn from the survey data on cooperative grouping.

## II. Hands-on activities (Tables 4–6)

Again, survey data do not match interview and journal results. The survey results show a significant decrease in positive attitude toward hands-on activities as a means to "learning well." On the other hand, interviews and journal responses point out the contrary.

## III. Graphical skills (Tables 7–9)

Results on attitudes of students toward graphing activities converge. When the data from at least three methods of qualitative data collection indicate the same results, then greater validity exists in the conclusions drawn and triangulation is achieved (Mark and Shotland 1987). This is the case with the attitudes of students toward graphing activities and their ability to construct and interpret graphs.

**TABLE 1**

**Cooperative grouping: Interviews**

| Interview | Question | Results |
|---|---|---|
| #1 | What do you think would be the best way(s) to prepare for an exam in chemistry? | 0 out of 45 said, "Explaining concepts to others." 2 out of 45 (4%) said, "Working in a group." |
| #2 | What are your opinions about the structure of this class? | 4 out of 17 (24%) said, "Different, not used to groups." 3 out of 17 (18%) said, "Groups are cool." or "I like groups." |
| #4 | Has this class helped you discover anything new about the way you learn? | 8 out of 17 (47%) stated that, prior to taking the class, they did not like group work or did not realize how beneficial it was. |

**TABLE 2**

**Cooperative grouping: Reflective journal entries**

| Question | Results | Examples |
|---|---|---|
| How does the structure of this class benefit your chemistry learning experience? | 30 out of 45 (67%) expressed positive responses to cooperative grouping. | "Allows us to know people from class and encourages us to learn from peers."<br>"Makes my life easier."<br>"What a person doesn't know, chances are the other two have an idea." |

**TABLE 3**

**Cooperative grouping: Surveys**

| Survey item | **Results: mean values** (standard deviations)<br>Likert scale: (5) strongly agree–(1) strongly disagree |
|---|---|
| "I learn well by working in a group." | Presurvey: 3.53 (0.94)<br>Postsurvey: 3.56 (1.05)<br>$p = 0.6794$ (Wilcoxon test)* |
| "I learn well by explaining concepts to others." | Presurvey: 4.00 (0.99)<br>Postsurvey: 4.11 (0.82)<br>$p = 0.5614$ (Wilcoxon test)* |

*At $p = 0.05$ significance level, these results are not significant.

## Discussion

Triangulation was achieved only in the case of monitoring attitudes toward graphing skills. On the other hand, bracketing of a possible range of results for the other two constructs, cooperative grouping and hands-on activities, was obtained. How can we draw accurate and valid conclusions from these data? One option is to take these results, modify, and repeat the procedure until the results converge (Mark and Shotland 1987).

A second option is to weigh results, taking into consideration multiple issues, including how the data were collected and under what circumstances, as well as the nature of the qualitative method of data collection. The divergence of the survey results suggests a need to investigate the use of the survey. A survey makes one-dimensional measurements of many constructs, while various forms of data collected through interviews and journals provide rich detail that adds depth to the information collected (Kidder and Fine 1987). Surveys work well to collect factual data on the demographics of students (i.e., class, major, gender, and so on) (LeCompte, Millroy, and Preissle 1992). However, using surveys to gather information on attitudes is much more complicated. In a survey, there is no way to identify possible misinterpretations of statements that can be identified during an interview. A specific example from our interview process is shown by the results on attitudes toward hands-on activities where a student believed not to be learning, "but understanding better." For this student, learning and understanding are two very different things.

**TABLE 4**

**Hands-on activities: Interviews**

| Interview | Question | Results |
|---|---|---|
| #1 | What do you think would be the best way(s) to prepare for an exam in chemistry? | 0 out of 45 said, "Hands-on activities." |
| #2 | What are your opinions about the structure of this class? | 3 out of 17 (18%) said, "Like not having straight lecture"<br>1 out of 17 (6%) said, "Not used to activity instruction."<br>1 out of 17 (6%) said, "I hate activities. You must come prepared for class, otherwise, it is very frustrating." |
| #4 | Are you learning from activities? | 9 out of 17 (53%) said, "Yes." or "Always learn something if you are doing something."<br>2 out of 17 (12%) said, "I am not learning, but understanding better."<br>6 out of 17 (35%) said, "I think so." |
| #4 | What learning methods help you learn in most situations? | 11 out of 17 (65%) chose hands-on activities from an extensive list of choices. |

**TABLE 5**

**Hands-on activities: Reflective journal entries**

| Question | Results | Examples |
|---|---|---|
| How does the structure of this class benefit your chemistry learning experience? | 16 out of 45 (36%) expressed positive responses toward hands-on activities. | "Hands-on activities give us a chance to see chemistry up close as opposed to taking a professor's word for it." |

**TABLE 6**

**Hands-on activities: Surveys**

| Survey Item | **Results: mean values** (standard deviations)<br>Likert scale: (5) strongly agree–(1) strongly disagree |
|---|---|
| "I learn well by doing hands-on activities." | Presurvey: 4.39 (0.69)<br>Postsurvey: 3.97 (0.88)*<br>$p = 0.0186$ (Wilcoxon test)* |

*At $p = 0.05$ significance level, these results are significant.

It is important to note that most of the positive responses obtained from interview and journal data came from questions formulated with no bias toward the teaching strategies. For example, to the journal question, "How does the structure of this class benefit your chemistry learning experience?" 67% of students expressed positive responses specifically toward cooperative grouping and 36% toward hands-on activities. These journal results added validity to the interview results. For example, 47% of the interviewees specifically mentioned the benefits of cooperative grouping when asked, "Has this class helped you discover anything new about the way you learn?" (during interview 4).

We also consider the number of responses a weighing factor. In this case, Wilcoxon testing was conducted on the responses of 36 students, completing both pre- and postsurveys, out of a total enrollment of 45 (80%). In addition, a total of 42 students responded to the journal question (93%) and 40 students were interviewed (89%). Therefore, the number of responses from the different qualitative methods was comparable.

It is also known that students generally give low scores to new instructional approaches in which they are required to become more responsible for their own learning (Felder and Brent 1996). This could be another issue that might affect survey results, whereas personal interaction in interviews and the open-ended journal questions present the construct in an appropriate context to measure actual student perceptions. A specific example was obtained when one student expressed, "I hate activities." However, the reasons for such a strong, negative feeling were very positive in terms of our instructional goals, "You must come prepared for class, otherwise, it is very frustrating."

## Conclusions

This article has presented how a triangulation scheme revealed that the most common data-collection

method, surveys, was the most unreliable for two of the three constructs, giving results that were inconsistent with those obtained from interviews and journals. In educational studies there is a tendency to rely heavily upon survey data since surveys are very efficient at collecting large amounts of data in a short period of time (Wiersma 2000). However, surveys and interviews are associated with higher possible sources of error than would be found when taking more quantitative measurements in part due to the response effect, the tendency to give inaccurate or incorrect information (Wiersma 2000; Struening and Guttentag 1975).

Our use of the triangulation method showed that relying on only one or two methods of qualitative data collection could lead to the misrepresentation of the results, especially when considering survey data only.

In response to our original questions, the conclusions are as follows:

- Different qualitative research methods exposed different meaningful issues, such as the case in which a negative attitude actually reflected the positive intent of a sound pedagogical approach.
- Triangulation was obtained on attitudes toward a more objective construct (graphing activities) as compared to the subjective ones (teaching techniques). However, this aspect should be further documented in order to be able to generalize this statement.
- Triangulation or bracketing may be proved invaluable to avoid gross errors when drawing conclusions, especially when surveys are used.

Based on our results we suggest the use of multiple methods of data collection in order to develop

**TABLE 7**

**Graphical skills: Interviews**

| Interview | Question | Affirmative Responses |
|---|---|---|
| #2<br>17<br>students | Can you graph a set of data?<br>Can you read and interpret graphs as well?<br>Can you graph in Excel? | 100%<br>100%<br>94% |
| #3<br>21<br>students | Has your graphing ability improved as a result of taking this class?<br>Has your ability to read and interpret graphs improved?<br>Has this class helped you feel more comfortable using Excel? | 5%<br>24%<br>38% |
| #4<br>17<br>students | Has your graphing ability improved as a result of taking this class?<br>Has your ability to read and interpret graphs improved?<br>Has this class helped you feel more comfortable using Excel? | 59%<br>41%<br>82% |

**TABLE 8**

**Graphical skills: Field notes**

| Interview | Question | Results | Successful* | Examples of field notes |
|---|---|---|---|---|
| #3<br>21<br>students | Confident behavior | 6 (29%) | 6 | No hesitation at performing the task. Knew exactly what to do. |
| | Neutral behavior | 10 (48%) | 4 | "I am trying to remember what I did last time." |
| | Lack of confident behavior | 5 (23%) | 0 | Tried many different ways to perform the task. |
| #4<br>17<br>students | Confident behavior | 10 (59%) | 10 | Performed task correctly at first try. |
| | Neutral behavior | 6 (35%) | 5 | Tried something, deleted it, and tried a different approach. |
| | Lack of confident behavior | 1 (6%) | 0 | "I really have no idea what I am doing." |

*Successful in terms of being able to construct an appropriate graph.

**TABLE 9**

**Graphical skills: Surveys**

| Survey Item | Results |
|---|---|
| "This course has given me more confidence in interpreting/explaining scientific graphs." | 17 out of 43 (39%) agreed that the course gave them more confidence in interpreting graphs. |
| "This course has given me more confidence in preparing graphs and tables." | 22 out of 43 (51%) agreed that the course gave them more confidence in preparing graphs. |

a full picture of the situation. The development of more integrated assessment strategies can create a system of checks and balances to ensure the validity of results. ■

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