Formative Feedback Report #2:

Overview of Attitudinal Outcomes and Learning Process Information About UW-Madison's New Traditions, Topic-Oriented Approach to General Chemistry (104) Course

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prepared for

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Learning through Evaluation, Adaptation, and Dissemination
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1. Introductory Material

This evaluation was funded by the National Science Foundation (NSF), "New Traditions: Revitalizing the Curriculum" (NT) grant (#DUE-9455928) awarded to the NT Leadership Team based in the University of Wisconsin-Madison Chemistry Department, College of Letters and Science. The NT Leadership Team engaged the UW LEAD (Learning through Evaluation, Adaptation, and Dissemination) Center to undertake this work. This document is one of a series of formative feedback reports providing information on the NT chemistry education programs at the UW-Madison.

This report is one of two by the LEAD Center that provide findings on NT's innovative approaches to a second-semester freshman chemistry course (UW-Madison's Chemistry 104). Whereas the first report provided an analysis of the quantitative data collected on two NT versions of this course,[1] this report concentrates solely on the students' and TAs' experiences in one of the professor's Topic-oriented Approach (TOA) to the course.

The evaluation was conducted by staff of the LEAD Center. The evaluation team consisted of Susanna Hornig Priest, as the project manager, and Debra L. Penberthy and Steve A. Kosciuk, as the project researchers.

1.1. Scope of Findings: Attitudinal Outcomes and Learning Process Information Only

Evaluative information is often divided into “process” and “outcome” components. In educational evaluation, two main types of outcomes are studied: 1) performance and 2) affective outcomes. "Performance" outcomes assessments are designed to examine the relationship between particular teaching techniques or strategies and student performance, such as achievement as measured by standardized tests. "Affective outcomes" assessments refer to measurements which seek to determine the effect of particular pedagogical approaches on attitudinal factors such as confidence, interest level, and perceptions of science. Assessing outcomes alone has important limitations. Although it may reveal what students are or are not learning, and how, if at all, their attitudes change, it may say little about the "process" by which students are learning or growing.

By "process" we mean what takes place in the classroom, the laboratory and out-of-class that students perceive as either helping or hindering them in their learning. These processes are important to document, as it is only through a strong understanding of them that other practitioners can understand and adopt the innovations their colleagues have successfully implemented.

1 See the LEAD Center report, "Formative Feedback Report #1: Statistical Overview of Learning Process Information about UW-Madison's General Chemistry (104) New Traditions Courses."

For the University of Wisconsin-Madison Chemistry 103/104 portion of the New Traditions program, the LEAD Center has been asked to evaluate the learning "process" and "attitudinal outcomes" only, and this report should be read with that important limitation in mind.

1.2. Purposes

One purpose of this evaluation is to provide the NT leadership Team, which includes the TOA course instructor, with formative feedback information on the course. Feedback information is "formative" when it is used by decision makers to reflect on and analyze the project's goals and processes and then make any needed corrections. A second purpose is to document the course goals, strategies and outcomes in order to give other interested practitioners the opportunity to learn from this experiment in the event that they may be considering adopting a topic-oriented approach to teaching general chemistry.

1.3. Research Questions

This study was guided by research questions pertaining to the students' and the TAs' experiences in this course. The overarching research question about the students' experiences is:

> How do the various course elements affect the student learning process? Elements of particular interest are:
>
> - the topic-oriented approach to the material,
> - interactive lecture techniques (ConcepTests),
> - writing-based assignments (problem sets, integrated lab reports) and exams,
> - voluntary groupwork (in the optional workshops or out-of-class).

Research questions relating to the TA experience are:

- How, if at all, does the TA experience in Chemistry 104 differ from TAs' past experiences in courses which did not utilize the topic-oriented, conceptual approach and did not incorporate groupwork?

- What effect do the extended staff meetings[2] for TAs have on coordination and communication among teaching staff?

[2] In an effort to increase staff communication and coordination, the TOA professor held extended staff meetings (2 hours per week) which the course professor considered a form of on-the-job-training. At these meeting, the instructors discussed course organization, lab preparation and other issues at length. In addition, the instructors divided into two groups. One group worked on creating quiz questions for the upcoming week. The other group worked through the assignments (problem sets and integrated lab reports) together in real time, as a group, in order to make sure the TAs understood the expected outcomes in the same way and to help TAs anticipate the problems that students might encounter with the assignments and be better able to provide assistance.

- What effect do the extended staff meetings for TAs have on the TAs' ability to be successful as instructors for this course, particularly with regard to the following:

    - understanding the expectations for students, especially for the problem sets and integrated lab reports,
    - fostering active learning by prompting students with questions and hints rather than simply providing answers,
    - facilitating the optional workshops, and
    - using cooperative learning techniques in discussion.

- How, if at all, does the time spent teaching for this version of Chemistry 104 differ from TAs' past experiences in non-NT courses? Do the TAs perceive a qualitative difference in the *way* they spend their time on this course vs. other courses?

As in any exploratory research project, especially one relying on inductive analysis, some important findings were outside the scope of the original questions.

1.4. Research Methods

We gathered both qualitative and quantitative data from multiple sources. Methods included surveys, interviews and observations.

1.4.1. Interviews

Students, TAs and the course professor were interviewed in the manner and for the purposes described below. See Appendix A for copies of all of the interview protocols.

Student Interviews
In the middle of the semester, we interviewed a sample of 14 students from the TOA section of Chemistry 104. Students were identified using a "quasi" random process: that is, student names were generated using a random number to produce a list of students to contact. However, the actual list of interviewees was modified somewhat to ensure that the resulting group was similar to the make-up of the entire class and was comprised of at least one student of each of the eight TAs. The proportions of those interviewed were roughly similar (given the interview sample size of 14) to that of the entire lecture, with respect to gender and ethnic categories, incoming ability indicators, and academic rank. See Tables 1-5 below.

Students were interviewed by either Kosciuk, Penberthy or Priest using an open-ended interview protocol designed to elicit information on their experiences in the course overall and with particular course elements. We made use of the data from these interviews in three ways. First, based on themes from these interviews we designed a small set of additional questions for the end-of-semester survey to test if, and to what degree, these

themes were indicative of other students' experiences in the course. Second, we drew upon the interviews to produce a full course description (below) of how students experienced the course, e.g., how they perceived the relationships among lecture, lab and discussion. Third, we used the interviews to explain the patterns in the survey data, e.g. to explain why particular learning activities were more highly valued than others, and to provide a qualitative sense of the nature of the students' experience in this course.

TA Interviews

In March and April of 1997, 7 out of the 8 TAs were interviewed using an open-ended protocol. We made use of this data in two ways: 1) to provide a check on and context for the students' experiences (as expressed in interviews and surveys) and, 2) to explore the experience of the TAs for this course.

Course Faculty Interviews

The faculty member for this course was interviewed twice, once at the beginning of the semester, and once after the semester had ended. The purposes of the faculty interviews were to clarify the research questions for this study and to fully understand the intent and form of the innovations he was using.

1.4.2. Surveys

The following surveys were administered. See Appendix B for copies.

Pre- and post-student surveys

In order to characterize the students enrolled in this class and to look for before-and-after differences, a pre-survey was completed early in the semester and a post-survey was completed at the end of the semester. The pre-survey questions addressed students' confidence in various course-related abilities and perceptions of the relative importance of a variety of learning strategies for solving difficult chemistry problems, for grasping difficult chemistry concepts, and in overall math and science learning in previous courses.

The post-survey asked the same questions as the pre-survey plus a battery of questions on the perceived learning impact of people, activities and materials on learning and confidence; students' interest in science and chemistry at the time of the survey and retrospectively at the beginning of the course; specific items about the laboratory experiments and the Topic-oriented Approach to chemistry (all of these questions were developed based on interview data from this study and the NT, Chem 103 study); confidence in various science and chemistry related abilities; time spent on the course; and whether they would recommend the course to a friend.

The composition of the survey respondents was roughly similar to that of the entire lecture, with respect to gender and ethnic categories, incoming ability indicators, and

academic rank. See Tables 1-5 below. This report provides an analysis of the post-survey only. For a full analysis of the pre-survey and the relationships between the pre- and post-responses, see the LEAD Center report, "Formative Feedback #1: Statistical Overview of Learning Process Information about UW-Madison's General Chemistry (104) New Traditions Courses."

Table 1. Survey and Interview Samples by Ethnic Category

Ethnic Category	Total #	Total %	Pre-survey Respondents #	Pre-survey Respondents %	Post-survey Respondents #	Post-survey Respondents %	Interview Sample #	Interview sample %
no code	18	5%	7	4%	5	2%	0	0%
African-American	3	1%	1	1%	3	1%	0	0%
Asian-American	17	5%	6	3%	12	5%	1	7%
Hispanic	9	3%	4	2%	6	3%	0	0%
White, non-Hispanic	306	87%	174	91%	207	89%	13	93%
Grand Total	353	100%	192	100%	233	100%	14	100%

Table 2. Survey and Interview Samples by Gender Category

Gender Category	Totals #	Totals %	Pre-survey Respondents #	Pre-survey Respondents %	Post-survey Respondents #	Post-survey Respondents %	Interview Sample #	Interview Sample %
Female	207	59%	108	56%	139	60%	9	64%
Male	146	41%	84	44%	94	40%	5	36%
Grand Total	353	100%	192	100%	233	100%	14	100%

Table 3. Chem 103 grade distribution by interview and survey status

Sample	A-AB	B-BC	C or below	no Fall 103 grade	Total
interview sample	23%	46%	8%	23%	100%
pre-survey sample	35%	39%	17%	8%	100%
post-survey sample	36%	40%	14%	10%	100%
entire lecture	35%	38%	15%	11%	100%

Table 4. Average Fall `96 G.P.A. and credits earned to date

Sample	G.P.A.	G.P.A. credits
interview sample	3.40	18.31
pre-survey sample	3.06	18.17
post-survey sample	3.06	17.27
entire lecture	3.06	18.96

Table 5. Distribution of students by their academic rank

Sample	freshman	sophomore	junior	senior	Total
interview sample	36%	57%	7%	0%	100%
pre-survey sample	51%	42%	5%	2%	100%
post-survey sample	51%	43%	5%	1%	100%
entire lecture	51%	41%	7%	2%	100%

Note: These tables are based on data from those who included a valid student ID number and whose student records contained the relevant demographic items.

Beginning-of-semester Teaching Assistant (TA) survey

At the beginning of the semester all of the course TAs were asked to complete a survey concerning their teaching background, perceptions of the TA's role, attitudes toward the course innovations and perceived needs for training to teach this course. Five of the eight TAs returned the survey. The primary purpose of the survey was to inform the course professor early in the semester of any training the TAs might need (a short, informal analysis document was prepared for the professor shortly after survey return) and to provide baseline information in order to be able to assess changes in attitudes or perceptions as expressed in the mid-semester TA interviews. Because of the low return rate, we do not report at length about the results of this survey. However, the survey responses did inform the TA interview analysis presented herein.

1.4.3. Observations

Observations of lecture (1) and TA meetings (2) were conducted to provide a context for analysis of the survey and interview data.

1.5. Methodological Note: Triangulation

Combining methods with different strengths and weaknesses, or "triangulation," is a common strategy in evaluation and in social science research generally. In survey research, since each respondent answers the same questions in the same order, the questions provide information on the variables of interest in a reliable way. However, the wording of survey questions always incorporates the researchers' assumptions (in this case, both those of the New Traditions leadership and those of the LEAD evaluators) about the important issues, even where some questions are left open-ended. Interview questions, on the other hand, may more easily be modified in response to the expressed interests and concerns of the person being interviewed. The case for the validity of interview data is often stronger than the case for the validity of survey data, in terms of appropriately representing respondents' points of view. However, interview data may be less reliable (in the statistical sense) than survey data because each respondent is not necessarily asked the same question in the same order with the same wording, and because in-depth interview designs include fewer respondents.

Of course, survey data more easily lend themselves to numerical summarization, while interview data require a more complex analytic approach and are less simple to present. In order to maximize the advantages of the latter, interview data collected by LEAD are analyzed inductively, using verbatim transcriptions; the themes and issues as presented by the respondents are allowed to guide the analysis. Survey and interview data that bear on the same issues are examined together, and each facilitates the interpretation of the other.

1.6. Information for the Reader

Quotations from interviews with students are indented with "R:" preceding material from the respondent (students, TAs or the course professor) and "I:" preceding material from the interviewer. The quoted material is presented as faithfully as possible to the speaker's intent. If additional text is necessary to understand the quotation in context to the rest of the discussion, it is added in brackets. An ellipsis (. . .) in quoted material indicates deleted dialogue occurring within the reproduced material. Deletions are made so that readers can appreciate the speakers' views on a particular topic without having to sort through the divergent twists and turns of the raw dialogue. A row of asterisks is used to separate material from different interviews where necessary for clarity. For purposes of confidentiality all teaching assistants are referred to as "s/he."

Specific verbal quantifiers are used to denote the relative size of a group of respondents who presented particular perspectives or described particular experiences in interviews. It is important to note that due to the nature of qualitative interviews, the size of a group that explicitly described a particular type of experience or viewpoint does not indicate the size of the group who had this type of experience or holds this view. Although the same interview protocol was used in each interview, respondents' answers often prompted discussion on a particular area that may not have emerged in other interviews.

The verbal quantifiers used in this report are:

"A few": used when up to 30% of those interviewed presented the perspective.
"Many": used when 30 to 70% of those interviewed presented the perspective.
"Most": used when 70 to 90% of those interviewed presented the perspective.
"Virtually all": used when 90% or more of those interviewed presented the perspective.

2. Course Description

Chemistry 104 is the second-semester of a two-semester General Chemistry sequence at UW-Madison. It is a prerequisite for Analytical Chemistry and Organic Chemistry. It is a large lecture course with an enrollment of approximately 350 students. Most enrollees have taken Chemistry 103. The General Chemistry course sequence (103 and 104) is a pre-requisite for many science majors.

In the Spring of 1996, one professor in the UW-Madison Chemistry Department who was involved in the "New Traditions" curriculum reform project piloted a new version of the course which he called a "Topic-Oriented Approach" to Chemistry 104. The defining features of this course are as follows:

- most of the material is presented in the context of a current topic;
- most assignments emphasize the importance of understanding the application of chemical principles to these topics;
- the use of math is de-emphasized and students are expected to engage in writing about chemistry as a way to develop their communication skills and demonstrate their understanding; and
- students are highly encouraged to work together on most assignments.

In his course syllabus, the course professor provided an extensive list of course goals. He wrote:

> This course is primarily concerned with the application of chemical properties such as bonding, molecular structure, thermodynamics, and kinetics to understanding the worlds around us. In this course you will
>
> - Develop a big-picture view of the study and application of chemical principles
> - Enhance your ability to discuss observable, macroscopic properties as the consequences of interactions occurring at the atomic level
> - Become acquainted with the cutting edge of chemistry-related technologies
> - Develop familiarity about how we know things (e.g., how do we know a buckyball has 60 C atoms?) and why things occur (e.g., why do diamonds form in the earth's interior?)

- Relate chemical principles to contemporary issues (e.g., the search for an AIDS treatment)

- Develop comfort with the application of estimation techniques and graphical methods for solving problems and viewing data

- Improve visualization, communication, and writing skills.

In the Spring of 1997, the course professor implemented this course for the second time. He considers the course to be still in an evolutionary stage. Below we provide a description of the TOA Chemistry 104 course as it was implemented during the Spring of 1997. This description provides context for the students' reaction to the course overall and individual course elements. It is based upon the following: interviews with the course professor, 6 of the 8 TAs who worked with him, and 14 students, and the evaluators' observations of lecture and TA meetings.

Course Format

Groupwork

As previously indicated, students were strongly encouraged to work in groups on most assignments. However, with the exception of lab experiments, students were not required to work in groups. Students were required to turn in individually written assignments. In addition, students could choose their study partners and lab groups; there were no assigned groups. In order to assist students in the formation of groups, a group sign-up sheet was posted for students who wanted assistance with this.

Lectures

There were two, 50-minute, lectures per week, during which the professor presented most of the course material. Frequently he tied the chemistry principles to current issues, using newspaper articles and other popular sources to make the material accessible. Based on the evaluators' observations and student and TA interviews, student participation was a primary feature of the lectures. Three to five times during each lecture, the professor used "ConcepTests" in which he asked the students to vote on the correct answer to a multiple-choice question related to the lecture material. If most students appeared to have the right answer, he usually provided a quick explanation of the correct reasoning and moved on. If the student vote was split or participation was low, he assumed that there was some confusion about the question and asked students to talk among themselves about the question in order to come to a better understanding; then he asked students to vote again. In some cases, he asked a student to volunteer to explain the correct reasoning for the question.[3]

[3] This implementation of ConcepTests differs considerably from some other professors' use of this technique. Based on the evaluators' prior experience with this innovation, this implementation is considered particularly interactive.

Discussion Section

Students attended two 50-minute discussion sections per week. Each section enrolled approximately 22 students and was lead by a teaching assistant (TA)[4], usually a graduate student, but in some cases, an experienced instructor. Because lectures often focused on the application of concepts, most of the TAs for the TOA Chem 104 course concentrated on clarifying basic concepts during discussion. Most sections were described as interactive, but similar to a lecture in that the TA was in front of the room answering questions and providing explanations. Several of the TAs incorporated groupwork into their sections, having the students work in small groups on problems while the TA roamed the room, providing guidance. Short, detail-oriented quizzes were administered during every discussion section.

Laboratory

There was one 3-hour laboratory period per week. The experiments were drawn from the Chemistry Department's Chem 104 lab manual, were from other sources, or had been specifically designed for this version of the course. Although the experiments in the lab manual had been redesigned to be more "inquiry-based," most instructors and students who were interviewed described them as very similar to cookbook type labs. Students generally worked in small groups of their own choosing on the labs. At the conclusion of each lab, students completed a very brief report which was worth a few points. Several times during the semester, students were asked to complete a 3-5 page integrated lab report (ILR), which tied several experiments together through applying them to a real-world issue. The course professor described these assignments as follows:

> [For the] first integrated lab report, the context is they've done three laboratories in different areas, and now they are asked to write a research proposal for their boss…So they are told that someone recently has made these blue light LEDs, and they think that the material is this. And then it asks them to write a research report of how they're going to identify that this is, indeed, the material, and explain to their boss why this is beneficial. And it gives them points that they should touch on…And it requires that they go back and revisit their data from the lab, which is something I was after--sort of tied up with this retention idea, is that you have to keep using some of the things that they've done…And so labs, often they complete it one week and then it's gone…And they never look at the data again, you know, they *might* review it for the exam. And I wanted them to actually *have to* go back and look at their data, and, in this larger context, think about [questions like], "What does all this mean? And how do all these things -- all these techniques they've learned fit together to look at a real material?"

[4] At least one of the assistant instructors for this Chemistry 104 section was a faculty assistant (FA). However, for the sake of brevity we refer to the group of assistant instructors as TAs throughout this report.

In addition, there was at least one hypothesis-testing experiment which required students to develop their own procedure. Students were required to complete the lab portion of the class in order to receive a passing grade. Students had the same TA for discussion section and laboratory. The course was designed to stress the connections between lab experiments and lecture topics; however, there were some synchronization problems when the lecture topics fell behind the labs.

Problem sets

Approximately 10 problem sets were assigned over the semester. Problem sets consisted of several challenging problems. Many of the questions required short essay answers. The course professor described the problems in the following way:

> We've given out problem sets which they're encouraged to work on in groups, and they almost have to because they're really hard. And they're not only hard, but they're very different from the kinds of problems they've seen before. The problems generally have had sort of a scaffolded nature where the first part may be fairly simple and may be like the kinds of problems that they're accustomed to seeing. And my complaint about how we've taught often is you take one little factoid or one little manipulation and you make *a* problem out of it, and then you have another problem which is some other small manipulation and they never get tied together. And so [for] these problems…we're asking them to tie them all together and apply them to real…chemical problems.

Students confirmed that they tended to work together on the problem sets because the level of difficulty almost necessitated it and because the problems seemed well suited to discussion among students.

Workshops

In order to provide time for structured groupwork and for students to get guidance from their TAs on the course assignments, the course professor added another classtime element to his course this semester. He established bi-weekly workshops in the evening during which students could come and work in groups on either their problem sets or the ILRs, whichever the students chose. The TAs facilitated the workshops, giving the students help in the form of guidance, but not walking them through problem solutions. Workshop attendance was optional.[5] TAs rotated workshop duties; therefore, many times students attended workshops with TAs other than the one they were assigned to for discussion and lab. In exchange for time spent facilitating the workshops, the number of office hours TAs were expected to offer was lowered.

[5] The course professor designed the workshops based on the design of the Freshmen Learning Community Program's (FLCP) weekly meetings. He participated in the FLCP during the Spring of 1996 and saw that these meetings provided a formally structured way for students to work together with the guidance of the TA, which made for more productive groupwork. Therefore he adopted this model for this second version of his Chem 104 course. For an evaluation of the FLCP, contact the LEAD Center.

Exams

There were two essay exams which were based on material from lecture, discussion, problem sets and laboratory experiments. The final exam was a mixture of take-home problems and multiple choice questions from the American Chemical Society. The results of these questions were analyzed by Dr. Diane Bunce to determine how, if at all, the course affected students' ability to perform on standardized exam questions.[6]

Textbook and Class Handouts

The course text, *Chemistry and Chemical Reactivity*, was supplemented with handouts which will be developed into a course packet for the Spring 1998 version of the course. In addition, based on student feedback from the Spring '96 pilot version of this course indicating that student sometimes unsure of what was expected of them, the course professor regularly distributed "Expectations Sheets." These were designed to clarify his expectations for students during a given time period.

Grading

Rather than grading on a curve, the course professor used an absolute point system in order to encourage cooperation among students. It was stressed that if students did not complete the lab portion of the class they would not pass the course. Out of 1000 points, the exams were worth 600, labs 200 and problem sets and quizzes 200. Assignments were designed to be integrated, in that the nature of the problem sets and the ILRs was quite similar to the exams.

Student Board of Directors

The course professor asked for student volunteers for a Student Board of Directors to meet with him weekly to provide timely feedback so that he could make any necessary, feasible modifications. In addition, in order to hear from a broader cross-section of students, the professor often spent time in the laboratory talking informally with students.

TA Meetings

In order to address the fact that some of the TAs had not experienced this type of course as students or instructors, the professor held extended (approximately 2 hours), weekly TA meetings. He considered the TA meetings a form of "on-the-job-training." In addition to the customary items of discussion for TA meetings (organizational issues and lab procedures) there were two other major agenda items: 1) one subset of the TAs worked

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[6] See Diane Bunce and Ewa Labuda's, *Final Report: Evaluation of Student Achievement and Use of ChemPages in General Chemistry, Second Semester (Chem 104), University of Wisconsin, Madison.* 1997. Washington, D.C.: Catholic University. Note: the analysis in this report does not take into account the fact that the Topic-oriented Approach professor did not cover certain topics that were covered in the two other versions of the Chemistry 104 that were studied.

together to create common quiz questions to address the need for consistency across TA sections, and 2) a second subset of the TAs worked through either the problem set or the ILR with the professor in order to create an answer key and make sure that everyone understood the key points related to the assignments; this answer key was intended for all TAs to use in grading, and as a reference for the TAs who facilitated the workshops. When working on the assignments, the professor modeled "guide-on-the-side" behavior for the TAs, meaning that he attempted to help the TAs see how to give the students appropriate, helpful hints by first determining where students were stuck, and then, starting from what students did know, assisting them in getting over their hurdles.

3. The Student Experience

In the following section we present the analysis of the student surveys and interviews. The survey analysis establishes general trends in the students' experiences, while the interview analysis provides more thematic information about the nature of these experiences.

3.1. Student Survey Analysis

All students were asked to complete a pre-survey during the first week of class, and a post-survey during the last week of class. The Chem 104 report entitled "Formative Feedback Report #1: Preliminary Statistical Overview"[7] provides comparisons across student survey responses from three Chem 104 courses: the two NT "treatment" groups and a "comparison" group. It also provides a full analysis of the differences between the pre- and post-responses for all three sections.

In contrast to "Formative Feedback Report #1," this analysis draws only on the TOA students' post-survey responses to determine the relative impact of various course elements. Because this course is still in a formative stage, this anlysis may contribute to the professor's efforts to fine tune the course by identifying its current strengths and weaknesses.

3.1.1. Perceived Impact of Course Elements on Learning and Confidence

People

Students were asked to rate the relative impact of various people (instructors and other students) on their *learning* on a seven point scale (1-7 with 1 being negative, 4 neutral and 7 positive). Friends/informal groups and TAs were considered most important for student *learning* (mean scores of 5.8 and 5.8 respectively) followed by the course professor (5.2), course organized groups[8] (5.0), and the Chemistry Learning Center[9] (4.6).

A similar pattern emerged when students were asked to rate the impact of various people on their *confidence* in their "ability to understand and do chemistry," except that TAs were considered slightly more important than friends and informal groups in this regard. Also,

[7] Contact the LEAD Center for a copy of this report.

[8] For most, if not all, of the TA sections of this course, there were no assigned student groups. It is possible that students interpreted this question to mean their lab groups, because they were required to work in small groups of their own choosing for lab, or the workshops, because they were required to work in groups at these meetings. Also, some TAs had their students work in small groups during discussion, and students may have considered this "course organized" groupwork. It is interesting to note that for each set of questions which asked about the impact of course organized groups 10-30% of the respondents marked "not applicable," whereas only 2-3% of students marked "not applicable" for the impact of friends/informal groups.

[9] Not all students made use of the Chemistry Learning Center: 42% (99 out of 233) of respondents gave the CLC a rating and the others marked "not applicable."

the TA, friends and informal groups and the professor were considered slightly less positive in terms of their impact on confidence in comparison to their impact on learning (means of 5.6, 5.5 and 4.9 respectively, also on a seven point--1-7--scale). Note that for each set of questions which asked about the impact of both types of groupwork, the mean response for friends/informal groups was at least .5 points higher than the mean for course organized groups. In summary, students were more positive about informal groupwork than course organized groupwork.

Course Structures (Different Classtimes)

Students were asked to rate the relative importance of various course structures such as lecture and lab on their *learning*. Discussion sections were rated most highly (mean of 5.8 on a 1-7 scale with a mid-point of 3.5), followed by workshops (5.3), lecture (5.1), and lab (4.6). The high rankings of discussion section and workshops are consistent with the high rankings of informal groups and TAs, because both the discussion section and the workshops emphasized interaction with the TAs and among the students.

The same pattern emerged for the perceived impact of each of these course structures (discussion, lecture, etc.) on *confidence*, except that students again rated each slightly lower (no more than 0.4 points on a seven-point scale) in comparison to learning.

Course Assignments and Activities

Students were also asked to rate the relative importance of particular course assignments and class activities on a seven point (1-7) scale. Problem sets and quizzes were considered the most important for *learning* (mean of 5.3 with 76% agreement[10] and a mean of 5.2 with 80% agreement). ConcepTests given during lecture were also considered important (mean 5.0 with 70% agreement). Most students also considered ILRs important for learning (mean of 4.6 with 64% agreement). Lecture demonstrations and regular lab reports were regarded more neutrally in terms of learning (mean of 4.6 and 53% agreement and a mean of 4.3 with 45% agreement respectively). The same was true of exams, although there was considerable variance in the perceived learning value of exams (mean of 4.2 with a standard deviation of 1.6). The lab manual, UW ChemPages, and the textbook were not considered as valuable as other elements (means of 4.4, 4.0 and 3.8 respectively).[11]

Similar patterns prevail in questions asking students to rate the relative importance of various strategies for solving difficult chemistry problems (questions 72-79) and

10 "Agreement" as used throughout the rest of this section means that when asked if they agreed or disagreed, the noted percentage of students gave a rating that was higher than the mid-point of the scale. In this case, 75.6% gave a rating of 5, 6 or 7 when the scale was 1 (negative) to 7 (positive) with 4 being neutral.

11 As this survey was administered to three different lecture sections of Chem 104, students were also asked about the value of Challenge Problems and Computer Exercises. To our knowledge the students in this version of 104 did not have such assignments. Therefore, we do not include these data in our analysis.

understanding difficult chemistry concepts (questions 80-90). For example, the three most valued strategies for both of these tasks were working with friends/informal groups, asking the TA, and working on problem sets. Other choices for strategies for grasping difficult chemistry concepts included the following, listed in order of average ratings--from high to low: working with course organized groups, doing the ILR, using the text, working on own, doing lab experiments, asking the professor and doing regular lab reports.

When asked about the perceived impact of the course assignments and activities on *confidence*, the student response pattern was similar, with a few exceptions. For example, quizzes were regarded most positively (mean of 5.0) followed by problem sets (mean of 4.6). Also, regular lab reports were regarded slightly more positively than ILRs (means of 4.4 and 4.3) and exams were regarded as the least positive factor in student confidence (mean of 3.8 with only 39% agreement that the exams had a positive effect on their confidence). Most activities were rated slightly less positively in terms of their impact on confidence in comparison to their impact on learning. The most significant differences were for problem sets (0.6 lower) and ConcepTests (0.5 lower).

Lab Experience Details

Survey questions 91-103 provide further information on students' laboratory experiences. Although 73% of the respondents agreed that labs helped them understand important concepts in the course, approximately half of these students showed the lowest level of agreement (a rating of 3 on a 0-5 scale). Students showed stronger agreement that the experiments helped them learn lab procedures (mean of 3.6, 85% agreement with 45% giving a rating of 4). Most students agreed that the labs and the lectures were related (mean of 3.3 and 77% agreement). The average student response to the question of whether or not they understood the chemistry concepts behind the labs before conducting the experiments was more neutral (mean of 2.8 on a 0-5 scale and 63% agreement). Students showed more agreement that they eventually understood the chemistry behind the labs (mean of 3.8 and 90% agreement). Most students agreed that while conducting the lab experiment, they "sometimes thought about the chemistry concepts behind the labs" (mean of 3.2 with 82% agreement).

Students showed fairly strong agreement that their TAs helped them learn from the experiments (mean of 3.7, 83% agreement with 36% giving the highest rating). Students also indicated strong agreement that their lab partners were helpful in learning from the labs (a mean of 3.7, 86% agreement with 27% giving the highest rating). Consistent with this finding, when asked if they felt that the members of their lab group contributed "about equally," most agreed (mean of 3.5, 81% agreement) and most indicated disagreement with the statement that they would have learned more from the labs had they done them on their own (72% disagreement with a mean of 1.7). Students showed strong agreement that they were effective contributors to their own lab groups (a mean of 4.1 with 96% agreement). Most students (73%) indicated that the allotted time for laboratory was enough to complete their experiments.

3.1.2. Self-reported before and after interest levels

Survey questions 50-61 asked students to indicate their interest level in six different aspects of science before the course and after the course. The table below presents the students' responses and the amount of change they reported. All scores are reported as means on a six-points (0-5) scale where 0 is negative and 5 is positive.

Table 1. Post-survey data on interest levels (end-of-course and retrospective beginning-of-course) of TOA-Chemistry 104. All scores are reported as means on a six-point (0-5) scale.

	Before	After	% change
Science in general	4.25	4.23	N/C
Chem in general	3.19	3.29	+3%
Taking more chem	2.88	2.75	- 5%
Chemistry major	2.34	2.20	- 6%
Pursuing science-related field	4.35	4.34	N/C
Working w/others to learn science	3.53	3.94	+12%

The "before" figures are retrospective self-reports of students' levels of interest in these items prior to taking the course and should be interpreted with this in mind. It is clear, however, that in these students' perceptions, this course was successful in maintaining and in some cases slightly enhancing their interest in chemistry and science. Consistent with the other survey data on the students' experience with groupwork in this course, the biggest change was that students indicated that their interest in working with others to learn science increased. As reported in "Formative Feedback Report #1," the self-reported before and after interest levels of the non-NT Chem 104 comparison students dropped (16-46%) on all but one item. Thus, the indication that the TOA-Chem 104 students maintained or increased their interest level on most items is worthy of note.

3.1.3. Post-course confidence in scientific abilities

Survey questions 62-71 were designed to assess students' confidence in various scientific abilities after the course. Table 2 presents the students' responses.

The student responses showed that on average they were most confident in understanding other areas of science and applying their knowledge to the real world. Students indicated the least confidence in their ability to understand the chemistry of lab experiments. As reported in "Formative Feedback Report #1," all post-survey confidence items for the NT sections were substantially higher than for the comparison (non-NT) section.

Table 2. Post-survey data on confidence items for TOA-Chemistry 104. All scores are reported as means on a six-point (zero-to-five with 5 being the highest confidence) scale.

Confidence in your ability to . . .	
Understand other areas of science	3.87
Apply your knowledge of chemistry to the real world	3.77
Perform lab experiments	3.76
Understand key concepts of chemistry	3.72
Succeed in this chemistry course	3.70
Visualize key concepts of chemistry	3.65
Solve chemistry problems	3.57
Succeed in a chemistry related discipline	3.45
Understand the chemistry of lab experiments	3.41

3.1.4. Testing themes from student interviews

We developed ten survey questions specifically for this version of the course (numbers 104-113) to test themes about the student experience that emerged from the 14 student interviews. All of these questions used a 6-point, 0-5 scale. Students indicated agreement with the statement that "using 'real world' issues and examples in this class *helped me to learn* the material more easily" (mean of 3.8 where the middle of the scale was 2.5 and 86% agreement). Similarly, most agreed that the topic-oriented approach *stimulated their interest* in the material (mean of 3.9 and 86% agreement). Students generally believed that the ILR helped them to understand the chemistry concepts behind the labs (mean of 3.4 and 78% agreement), and that the emphasis on writing for the course assignments and exams helped them learn the course material (mean of 3.5 and 85% agreement). They also indicated some agreement that the ConcepTests posed by the professor during lecture helped them "stay interested in what he was saying" (mean of 3.2 and 74% agreement). They showed strong agreement that "working with other students helped me a great deal

in this class (mean of 4.1 with 91% agreement). Consistent with other survey data, they indicated agreement that the type of assistance given by their TAs helped them learn the course material (mean of 3.9 and 88% agreement) and that their TAs generally understood what was expected of the students on assignments (mean of 4.0 with 89% agreement).

When asked the degree to which they agreed to the statement, "As a student in this course, I felt confident that if I studied for the exams I would do well," students were more neutral. The mean response on a 0-5, 6-point scale was 2.79 and 59.3% agreed, e.g. gave a rating of 3, 4 or 5. Students were also neutral about whether they would have preferred a more traditional approach to Chem 104 in which math and chemical equations were emphasized more heavily. The mean response was 2.5 and 53% agreed (17% indicated the strongest degree of agreement--roughly equal to the percentage of students who showed the strongest degree of disagreement, 18%).

3.1.5. Overall Indicators

The students were asked three questions that were intended to elicit their overall perceptions of the value of their Chem 104 experience. Most students indicated that they were confident that having taken Chem 104 they would be prepared for subsequent chemistry courses (mean of 3.5 on a 0-5 scale where the midpoint was 2.5 with 86% agreement). Sixty-seven percent of these respondents indicated that they were, in fact, planning to take more chemistry. Similarly, most students agreed that having taken Chem 104 they would be prepared for additional *science* courses (mean of 3.8 with 90% agreement). When asked if they would recommend this course to a friend, 85% agreed, with 18% showing the highest degree of agreement and 8% the highest disagreement (mean of 3.1).

When asked how many hours they spent on this course outside of lecture, discussion and lab, approximately half (45%) of the students indicated that they spent 5-10 hours, the majority of the other students were either below the figure, at 0-5 hours a week (25%) or slightly above this figure at 10-15 hours per week (20%). Consistent with the other data supporting that students worked together frequently in this course, more than half (54%) of the students indicated that they spent 5 or more hours per week working with other students, while the other 46% indicated that they spent 0-5 hours per week working with others. The responses to the above two questions suggest that most students spent time both working alone and with other students.

3.2. Explaining and Corroborating Themes from the Survey Data through Student and TA Interviews

Having presented the patterns in the student survey data, we now drawn upon the student interviews for explanations of these patterns. For example, why was informal groupwork so highly valued and why were problem sets and quizzes the most valued learning activity in this course? In addition, we have used the student interviews to develop a qualitative sense of the *nature of* the students' experience in this course. For instance, whereas survey data indicate that, overall, the students considered this a positive learning experience, the interview data can tell us why and what was positive or negative about it. In addition, some survey trends which were only partially explained by student interview data were better explained from the perspective of TAs during their interviews. In these cases, we present TA interview data as well.

3.2.1. Overall Themes

Consistent with the survey data, student interviewees indicated that, overall, they felt that the course was designed in such a way that they were able to have an effective learning experience and that, compared to other courses, they learned a lot. However, students did discuss some significant problems with course organization and the implementation of particular elements. These problems made their experience somewhat less beneficial and enjoyable and suggest areas for further modification of the course. Below we present some salient overall themes which are supported by both the interview and the survey data. In Section 3.2.2 we discuss the students' reactions to particular course elements.

3.2.1.1. Perceived effects of innovative approach to chemistry

Maintained interest and fostered a deeper understanding

As indicated in the survey data, the TOA Chem 104 was effective in at least maintaining student interest, if not increasing it. In their interviews students confirmed that because the course material was presented in relation to "real world" issues, some of which were already familiar, they found the material more interesting and relevant.

> I: What do you think of [the course professor's] use of real world [examples]. How does that affect your learning, if at all?
>
> R: I like it because it not only helps to understand, but you actually want to know. It's like, "Oh really, why is the whatever like that?," and you're like, "Wow, I never knew that." And you feel like you actually know something that people in general would want to know, instead of just like ,"Oh, wow. I learned how to balance an equation today. Woohoo!!" Like anyone really cares about that. Like you can go, "I know why the octane is higher. I know why, " It's about stuff that people

wonder about.

****

Yeah, I definitely like [the Topic-Oriented Approach]. It's great. Whenever he'll experiment in lecture or something, like a demonstration, he'll say, "Want to know how acid rain works? Well, this is what it does to a ring." Instead of like, "Here's some helium, and [we do something to it, and] so a fire starts." [I would be thinking,] "What does that have to do with anything?" …So, I like it a lot. It's a lot more interesting.

****

Well I guess the biggest thing that's struck me about the class is the chemistry concepts are applied in so much more places than what you think. Like the whole thing with, we talked about octane for a while…and you know, my dad's like an absolute car genius and you know, it helps to be able to figure [things] out, like when you see octane on the gas pumps or whatever it's interesting to be able think about how things work, you know? By just like a simple ground knowledge of it, you know, be able to apply it like right away.

They also felt that, in some cases, the course gave them a deeper understanding of the chemistry concepts. Students indicated that this deeper understanding was not due solely to the use of "real world issues," but also to the emphasis in the assessment structure (assignments and exams) on demonstrating conceptual understanding and to the students' heavy participation in voluntary groupwork, where they engaged in conversations with peers about chemistry. A typical comment about the value of writing-based assessment follows:

I: So, now, this thing that [the professor] is doing, where you have essay questions, rather than just doing calculations; do you have any comments about that?

R: Yeah, it helps you, it helps me with more of the concepts…Instead of just like putting a formula on and plugging in the numbers, and getting the answer. It makes you really have to think about what's happening, and like the outcomes, and the results.

Many of the interviewees also indicated that they felt they would retain what they had learned in Chem 104 more than in other chemistry courses because of the nature of the learning experience.

R: Well, I think my other classes will be easier based on how well I did in this one. Because I have to take organic chemistry, and we did a lot of organic in this course. Like I think I won't remember the stuff completely, but I will catch on a lot more quickly, it will come back to me quicker…because I understand it.

I: …Was there anything in particular about this type of course, about 104, or just having-

R: Just understanding…I didn't understand really what I was doing in 103. I was just regurgitating stuff…And understanding is like easier to remember from…Like [in 103 on exams] I would just narrow down [the answer from the available choices], like, "Oh, OK, um it's this [one]," whereas for an essay exam there is nothing to narrow down. It's like, "I think it's this because--" you have to explain you're reasoning, you know?

****

I: What about the general emphasis on writing, writing for chemistry. What was your reaction towards that?

R: I never really had to write about chemistry before. Um, I think it helps you to understand it better, more than just going through-

I: And doing problems?

R: Yeah.

This interviewee, like several others, went on to explain that although the conceptual approach was "probably good," they did not necessarily like the added challenge.

I: OK, well how do you *like* it?

R: I don't really care for it that much, it's more difficult but (pause). I have a difficult time trying to like, explain everything. It's like a lot of explanations…which will probably stick with you longer then if you just went through a number problem. So it's probably good in the long run.

As illustrated by the following TA quote, several TAs indicated that they too felt the students would come away with a stronger understanding of the chemistry concepts because of the topic-oriented, conceptually-based approach.

R: I think they get a deeper understanding of the chemistry, and not just the math and solving the problem.

I: And what's the source of that? How is it that they get the deeper understanding?

R: I guess part of it is the way the lecture is presented, you know. It's like the topic-oriented approach. We're using different types of chemistry to explain an

> observation. You know, we had a unit on, like, Buckyballs and diamonds, and semi-conductors. Well, there was a lot of very descriptive chemistry, but it was actually kind-of high level understanding. But, you know, I don't know if I would have them out there cranking through a lot of these mathematical problems. I don't know how successful they would be. I mean, they would be OK…[But] you forget the math, you know, when you leave class you forget how to do a problem in a couple months. But it's been my experience, and I know other people have thought this way too, that once you learn conceptually how something works, you know that will always stick with you. And so when it comes later for you to learn how to do analytical class or something you know what's going on, and the math just grows out of that.

Another student indicated that being exposed to the connections between chemistry concepts and real world issues made cutting edge science seem more accessible to him.

> R: …The interesting part about [science] is that you always hear about someone somewhere who's supposed to be a genius and who is figuring out how to, you know, do all this with lasers. But, you know, we kind of struggled through that integrated lab report on constructing this new kind of laser you know, but after you figured it out, you turned around and said you know, "Well it's not really that difficult, you know I, I'm kind of getting at the same concepts that all these people are working on."
>
> I: Oh, so you feel, you felt like you really understood a difficult thing?
>
> R: Yeah, well I mean it, in some of the problem sets that we do, the thing that I appreciate most about the problem sets in the integrative lab reports, is it makes it seem like all the concepts and all the things that are being done in science today, which you know, you know they're great accomplishments, but they're done by like such accomplished people that it seems like they're so far away, something that you never would be capable of understanding. But when he brings [in] these more abstract concepts, you know, like using something that will allow more data to be stored on a CD-ROM, it makes it seem like these concepts aren't that hard or difficult to grasp, if you have grasp on like the concepts that are behind it… and I, you know I like how it doesn't seem so far away anymore. Like if you see on the cover of *USA Today* the whole cloning machine thing or something like that, it doesn't seem so far away anymore. A lot of the same things seems to happen with like the problem sets in the integrated lab reports and things like that.

Although students indicated that the overall approach helped maintain their interest in this course and kept them engaged in their assignments, they tended not to say that the course had increased their interest in pursuing more chemistry. Also, while for the most part they came to see that chemistry was more relevant to the world around them, the course did not appear to change their career interests.

Produced difficult adjustment period

The student interviewees and the TAs indicated that the course professor's approach to chemistry was new to them. The students felt there was an adjustment period at the beginning of the semester. Some experienced difficulty adjusting to the emphasis on writing about chemistry, as opposed to performing equation-based calculations. Others reported difficulty approaching chemistry concepts in a less linear fashion. They explained that because the real-world topics related to more than one chemistry concept they felt they were jumping from concept to concept much more than in their past chemistry courses. The following two student interview excerpts are representative of the interviewee's comments on this issue.

> Initially, I was upset [about the course]…It was different and overwhelming at first. I mean, my first semester was like, "Okay, we're going to study chapter 10, and chapter 11, and chapter 12," and there were tests on it. This is like, all over. He's pulling stuff from all over, and it's not as concrete, you don't know exactly what you're supposed to know. It was like, it was a little upsetting at first. I think I got used to that, but it's still something that's not -- I don't think it's easy to prepare for a test if it's that way…[And also] it's like our problem sets, which were really conceptual, and that's working in groups, which are nice. They're--you know, it's using things. You're now thinking it all over and writing, like, essays about stuff, you know? It's interesting. I think in some ways it's good because it does really cause you to think about things and tie things together, which is good and it's going to help you learn. But, it's hard, you know, because we get to meet in a group to, like, think through everything, which when we got to the tests, the problems were similar, but you only had yourself, then. And that was difficult.
>
> **********
>
> I: What were first impressions of Chem 104 in the first two weeks of the class?
>
> R: Um, I thought it would be hard. The first problem set we got, it was really hard. I was intimidated by it.
>
> I: …What was intimidating about it?
>
> R: It was like, most of the classes in high school and even first semester, it was just like real straight-forward, and you had to apply it a lot, and now it's like you have to figure out how to apply it to different things which is hard… It was harder than I thought it would be…It didn't come real easy…I'm enjoying the class, but…

It is difficult to ascertain when or if this adjustment period came to a close, as interviews at the end of the semester were not part of this study.

Produced some concern about lack of more traditional chemistry skills such as "plugging-and-chugging"

Although students discussed that they were learning a lot and learning more deeply than they had in past chemistry courses, some expressed concern that they would not be prepared for standardized exams such as the MCAT and future chemistry courses. They recognized the value of the emphasis on the conceptual understanding in this course, but still wondered if they were getting enough of the traditional "plug-and-chug" abilities that they might need later in their academic careers. These students indicated that they were aware that this question would go unanswered until they faced those future situations, but that currently it caused them some concern.

> I: OK. Are there any drawbacks to it? Anything that's a concern at all?
>
> R: Um, if I had anything concerns at all, it would just be that I want to go on and do more chemistry courses, [and I'm wondering] how this course is going to prepare me for that. And I couldn't answer that question right now.
>
> **********
>
> I: How have you felt this semester as far as your preparation [for future science courses]?
>
> R: Um, it's hard to tell in terms of, like, I'll have conversations with other students who have different professors, and it seems like we're doing different things. Learning different things…We're learning, like the concepts behind everything, and not necessarily the basic things, which I think is good in some ways but in other ways you need to know about different things, which I don't exactly learn…[For instance,] I've learned the concepts, but not like, the basic equations and stuff…like the problems, like plugging numbers in, we don't do that really. More just kind of, like, what's happening.
>
> I: And you said you feel like you were a little bit worried because you feel like you're possibly missing things?
>
> R: Yeah.
>
> I: Is that for other courses, or where do you think you might--
>
> R: Yeah, well, I mean, I'm pretty good in organic chemistry, …but there are things I need to know.
>
> I: Yeah, so what do you think is going to happen when you take those courses?
>
> R: I just don't know. I think {pause} I think the concepts will stay with me, so

> that will be good, like maybe I'll remember the concepts. And that might be more important in the long run, but it doesn't help at this point. I don't know.

About half of the TAs expressed similar concerns. As in the following TA quote, they tended to say that depending on a students' planned major they needed different types of Chem 104 preparation, and that for chemistry or pre-medicine majors, the TOA Chem 104 might by lacking. Most felt that for other majors the TOA Chem 104 provided strong preparation.

> R: I think they do maintain the concepts better, not necessarily the mathematical formulas, but they do learn, they maintain it for a longer time, although they may not know everything they need to if they are going to take the ACS Chem test or if they're going to go on to medical school…
>
> I: And so you think that this might hurt some of them?
>
> R: Yeah, if they're pre-chem, basically. If they're just like engineering or even nursing, I don't think it matters.
>
> I: Biology?
>
> R: [For] biology [that type of preparation] doesn't matter, I don't think.

Seemed to require more student background knowledge

A few students indicated that they sometimes felt that the course required a lot of background knowledge that they didn't necessarily have. For some of the respondents, such as the one quoted below, it was difficult to ascertain whether they meant knowledge about chemistry or about the real world topics used in the course.

> R: …the way the material is presented, is--in a way, it requires a lot more thinking. You can't look up the answers, you have to think about it enough to come up with an answer on your own, it's not there, you can't just pick it out of a book. A lot of the time, I think that a lot of background knowledge that I [don't have is required]
>
> I: Hmm what kind of background knowledge?
>
> R: Well because like, umm. A lot of times the stuff is not stuff I just know…

For other students, such as the one quoted below, it was clear that they were speaking about an expectation that the students understood certain chemical concepts.

> I think that a lot of times since they are such current topics, I think he sometimes assumes that we have background knowledge that we don't necessarily have. And depending on the Chem 103 course that we took, we're all coming in there with

different knowledge and our chemistry course in high school. So, especially with this new stuff, he just kind of jumps right in, and we're expected to have this background knowledge that some of us just don't have…[For instance], right now we're doing acids and bases, and I mean we covered that in high school..., but I took that my sophomore year so it's been a few years ago, and then in Chem 103 there was nothing major [about it]. So now when we're doing acid/base chemistry and equilibrium, I really don't have a strong background in that and he's just kind of jumping in. I've tried to read the book, but I think it's just hard to learn just straight from the textbook without some clarification from the professor or TA. So I'm trying to do what I can, but I don't have that background knowledge really.

Created some difficulty separating concept from the application

Students indicated that at times it was difficult to understand the basic chemistry concept in isolation; it was difficult to separate the application from the concept. In these cases, students felt that they were missing the basics.

I: So, does the application aspect of lecture help you learn at all? What does that do for you?

R: I find it confusing sometimes. I like the idea of applying it, I think it makes it more interesting, but I do find it difficult to grasp the general concepts then…I'd rather get the basic concepts and then apply, rather then try and get the basics from the applications.

****

I: [What does it do for you when the professor approaches something in this way?] "We're going to study acid rain, and try to figure out the chemistry, how the acid based chemistry is related to the chemistry of acid rain," or something like that.

R: It's good to a point, but when the only proteins that you can relate to are HIV protease, and you can't, I don't know if enough students out of the class can see the general trends and maybe in a different enzyme or something like this, instead if you focus on HIV protease or the only acid based reaction is acid rain, if those become your focal points, and you can't see--

I: Oh, I see, you're losing some of the generality.

R: Right.

I: By focusing it on a topic, you're worried that some students might be losing the generality of the chemistry that deals with that topic.

R: Right. Exactly

In addition, they felt that it would be difficult to apply those chemistry concepts to examples other than the ones through which they were presented. Some students indicated that their TAs' primary role was to follow-up on the lectures and help the students understand the chemistry concepts apart from the examples the course professor used during lecture, and that this greatly enhanced their understanding. Other students who indicated that their TAs took a slightly different approach, offering less of this type of assistance, tended to express more concern that they were not understanding the basic chemistry concepts. Given the small interview sample, it is difficult to say if the difference in TA approach was responsible for this variation.

3.2.1.2. Logistical and calibration-related difficulties

The student interviewees discussed several problems they encountered during the course which were related to logistics or calibration of the level of difficulty of the course material for first year chemistry students.[12]

Planned integration of course elements planned partially successful

Students indicated that, particularly at the beginning of the semester, lab and lecture were well coordinated and it was easy to see the relationship between the experiments and the material presented in and problem sets assigned for lecture. Toward the middle of the semester, however, the lecture often fell behind the labs. Students indicated that when this happened they often did not understand the purpose behind the lab experiments until long afterwards when they completed the ILRs. In these cases, they felt that they learned less from the experiments than when the lab and lecture were well coordinated. Still, students indicated that the first ILR forced them to think deeply about and apply the concepts illustrated by the experiments and that this was a significant learning experience. (Note: All of the student interviews were conducted prior to the due date for the second ILR.)

Coordination and integration of assignments uneven

Students discussed that the first ILR was due just prior to the first exam and provided strong preparation for that exam because it made them grapple with the important concepts for that segment of the course. The second ILR was due after the second exam, however, and because the ILRs were the primary vehicle for understanding the labs, they may have been less able to draw upon all their lab experiences to prepare for the second exam.

[12] In his interview, the course professor discussed that each of these problems were issues that he was aware of and planning to address. He also stated that these were the types of problems one could expect when creating a new course for which there is no appropriate text to provide a guiding framework.

In addition, the problem sets assigned prior to the first exam were seen as strong preparation for the first exam; students indicated that the material was similar, although the exam questions were a bit more difficult. With the second exam, however, the students felt that the problem sets bore much less relation to the exam questions.[13] They felt that what they had spent their time on, learning and preparing for the exam, was not really tested for by the exam. Thus, the students found the exam extremely difficult. This was quite frustrating to the students. The course professor, upon seeing how poorly the students did on the second exam, allowed the students to have their exams back and to redo a large portion of it for credit. The 5 interviewees who spoke to this issue were divided in their reactions. Some greatly appreciated this chance and interpreted it to mean that the course professor really cared that they learn something from the exam. Others felt that this just gave them more work to do in a limited time and meant that the exam was not well designed.

Level of challenge uneven

Some of those who were interviewed after the second exam expressed that the level of challenge in the course had been uneven and had increased greatly. Most interviewees indicated that the course was challenging from the beginning, but that they had done reasonably well on the first exam. Student reported that after the first exam, however, based on feedback from some students that the problem sets were not challenging enough to fully prepare students for the exam, the course professor decided to raise the level of expectations for the problem sets. Some students indicated that at this point the problem sets became much more difficult and some felt that the course professors' expectations became too high. The following student interview quote illustrates this point.

> We have these workshops we go to, and sometimes he makes the problems so hard that you'll go to the workshop four hours during the week and basically your TA prompts you on every question because it's so hard to figure out alone. You could sit there for hours and stare and not be able to do anything. So I don't know, I think he's gone a little bit overboard with challenging us.

A few students, including the one quoted above, indicated that the extremely challenging nature of the course negatively affected their confidence. For example, another student stated that because of the level of difficulty she was experiencing with the course, she had begun to doubt her abilities and reconsider pursuing science.

> R: I guess I've almost just become a little scared of chemistry, because [in the past it's always been that]…if I get a bad grade it's been my fault. It's been because I haven't studied, or I haven't gone to lecture, or I haven't done everything. And

[13] It is important to note that only 5 of the 14 student interviews were conducted after the second exam. Therefore it is possible that this view was not widely shared. However, survey data suggests that a strong minority of the students (41%) did not feel confident that if they "studied for the exams" they would do well.

most recently I've gone to every lecture, every discussion, every lab, done all the readings, all the problems, and studied five or six hours, and still not had a clue. And I don't like that. And I don't know if that's the reality in chemistry. My other friends in [other Chem 104 sections] grasp it there, I mean it takes work for them but it's there. So he's got me, you know, back-peddling, thinking, you know, "What's going on?"

I: When you talk to about other friends who seem to be grasping it, are you talking about in this 104 class.

R: No. Other sections of 104. It's hard, and they put in work. But they can look back and be like, "I could have known this." I can't say that all the time. When I do stuff for this class, I can't feel that there is any way that I could have known it, despite how much I've studied. And I don't know if [the professor] makes it extremely hard, or if that's just the reality of chemistry for me. So that's why I'm like, "Do I want to go on, or don't I want to go on?"

I: Hmmm, that would be difficult, because it's hard to say if you would have the same experience in another course.

R: Yeah, I mean on one hand I don't think I would, because of the people I've talked to. But on the other hand, he's got me in such a mentality of thinking that chemistry is so beyond me, because he's trying to apply it too much so that I don't want to deal with it.

Again, because only about one-third of the interviews were conducted after the second exam, it is difficult to ascertain whether or not this experience was idiosyncratic. We mention it here because we feel it is an issue worth exploring further during future implementations of the course.

Overall, some students discussed that they had not adjusted to the fact that, unlike in their past educational experiences, in this course their self-assessed level of achievement did not seem to correlate directly with the amount of effort they expended. For example, some indicated that they did not feel confident that if they studied for the exams, they would do well, because, unlike most exams in the sciences that they had taken before, the subject matter was not discrete and the task at hand was not one of memorizing and developing the ability to solve equations by working similar problems. This was somewhat frustrating for the students, especially those who were highly grade motivated, and/or needed to do well to get into medical school. The evaluators believe that this feeling was less associated with the letter grade students ended up receiving (which was often high) than with the self-assessment of how well or how poorly they had done on an exam. For this reason, we speculate that this *feeling* of having done poorly on an exam could have had a detrimental effect on these students.

Student survey data confirms that this feeling of underperforming on the exams was common. Because the interview sample was small and we wanted to determine how widespread this experience was, we pursued this theme on the student survey. We asked students how much they agreed with the statement, "As a student in this course, I felt confident that if I studied for the exams I would do well." The mean response was neutral and 40.7 % disagreed.

Assignments came in waves

Interviewees discussed that this course required them to work a lot outside of class. Although a few considered the workload unreasonable, most seemed to be indicating that the workload came in waves where a lot of work was due at once. For instance, the first ILR was due just prior to the first exam. This concentration of work made for several periods of high stress during the course.

The TA quoted below discussed that s/he felt that this concentration of work into a few large assignments and exams might have the negative effect of causing students to wait to do their work in spurts, and not work gradually, day by day to understand the material.

> I think originally the idea was you keep them caught up by giving them these quizzes. Which, you know, works sometimes, and other times it doesn't…[because] they're [only worth] three points, or something like this, and [students think,] "Ah, if I miss a three point quiz out of a thousand points, you know…"And I know he's trying to [make expectations clear]…with this expectation sheet that he sends out every week or two to the students. And it has homework problems on, but these are problems you should try. And you know students are bogged down with a lot of work, and if there's something on the periphery that they don't have to turn in, …they're not going to do it, you know. So, there's this problem between you not wanting to have to force students to do this work just to do it, to get a grade. And, I mean, ideally you wouldn't want to do that…You don't want to just [have them] turn in all this busywork…And on the other hand, you want to present them with something where they're motivated to learn, and it's interesting, and the problems that you do ask them to do, it's, you know, applying your knowledge, in-depth. Which is what he's trying to do, but at the same time, they're not necessarily keeping caught up on a daily basis or something.

This TA provided the following suggested solution.

> Yeah, maybe there's something where they have a very hard problem set at that period of time, but you assign smaller homework sets that build up to the problem, and prepare them to do the problem set…Because half this last problem set I couldn't even answer {laughter}…I was like, "Oh geez, it's been so long since I've looked at any of this stuff, and…So, I think more steps along the way, and constant use of the material--doing it--would really be helpful."

3.2.1.3. Voluntary groupwork quite successful because of the nature of the assignments

Although the groupwork was almost completely voluntary (except that students were expected to work in groups of their own choosing for lab experiments), most of the students who were interviewed indicated that they spent considerable time working with other students on the course assignments. Most had at least one study group, and some had a few different groups with which they worked. (A few students who were interviewed did not, however, have a study group.) These students indicated that the nature of the assignments (the problem sets and the ILRs) was such that they were conducive to discussion and challenging enough that students felt it was almost necessary to work with others to do well and understand the material.

> [The problem sets were]…really scary in the beginning and I think I've just gotten used to them, but it is like a whole different level than just from like...it makes you connect different aspects and stuff and so...I don't think I would ever be able to work through one of those by myself. I think I really rely on the groupwork, which is interesting because I've heard some people just say that they can just do it by themselves and I just don't see how they can, because I just find it a whole different level of learning. I think they're difficult…The first time you glance at them it's really frustrating and it's like, "I'm never going to get anywhere." But once you sit down with your group and you start going through it, it really helps and it usually takes about two of those [workshops] to get it done.

****

> R: [My study group is] a really good group, so I'd be foolish not to use them as a resource even though it wouldn't be essential for me to--
>
> I: But is it a good use of time, is it more efficient to work through the problems with the groups or--
>
> R: Yeah, because the problems challenge you enough that you wouldn't be able to get it all on yourself, by yourself I mean. So, yeah it's more efficient to have the group there.

One student who stated that it was highly necessary for him to work in groups this semester went on to contrast the problem sets for TOA 104 with those for 103.

> …Like in last semester's chemistry class, I don't know if there was really that much of a need to go find help from other friends. You know, the problems in the back of each chapter are, you know, they're pretty tough, but it's almost easier to just email your TA or something for help, because it's not going to be that much of a deal for them to help you on something like that. You know, it's just like, "Oh you're forgetting which one is the limiting re-agent," or something, and you'll like smack yourself on the forehead and go do it over again. You know there's a lot

more logic involved in those.

An additional reason students gave for working in groups was because the course professor actively encouraged it by repeatedly stating that students should form groups and providing mechanisms such as the workshops to facilitate this.

> I: And why does it happen [that students work together voluntarily] in this course?
>
> R: I think he encouraged it. He always said, "Get with your friends." …So, it just seems more natural, if the teacher says, "You guys should form study groups." It's like, "Oh, yeah. Sure. OK." Everybody agrees with it, everybody knows that it's OK, everybody else is thinking, "We should form a study group." So then forming a study group, it's no problem to get it together. Instead of just walking around and asking people if they want to study.
>
> I: It would be kind of nerdy? {laugh}
>
> R: Yeah!…But when the teacher says "Form study groups, I'm expecting you to form study groups, and this is your problem set and the whole reason I'm giving you a problem set is so that you can get together with other people and talk about it." Then it's like, "Well, yeah, if everybody else is getting together and doing it, I'm not going to just sit here and do it myself!" It just makes more sense to do it with other people.

Both survey and interview data suggest that, for the most part, students' experience with groupwork in this course was positive. Students discussed many positive benefits from groupwork such as learning the value of other perspectives, learning from teaching their peers, and developing the ability to talk about chemistry.

> I think it helps me a lot if I help another student…like I got the first integrated lab report done really quick, because I worked a little bit with CD-ROM technology and stuff like that in high school…So that came pretty easy to me. But you know I think it really cemented the ideas when I came and tried to explain them to other people. You know, because if there's any fault in your logic, you know, if there was any step missing, if they're all people who are, you know, similar to you, you know they're going to pick out a little fault in your logic.

Based on interview data, there appears to have been less incidence of common groupwork problems such as "slackers"--those who rely on the group too heavily and contribute very little--and "dominators"--those who control the group and make it difficult for others to contribute effectively.

> …This is another thing that I've been very impressed with [in this course], the students are really getting together, really working well together, I think. And, I

don't see anybody, you know a lot of times in group work you run the risk of somebody doing all the work and, that happens to an extent…but overall, everybody chimes in with something.

****

I: What are the dynamics in your group?

R: Good. We all get along real well. We're all friendly.

I: OK. And would you say that there's a sense that everybody's pulling their weight?

R: Yeah. There's no slacker in our group.

I: And how did that come about, do you think?

R: I don't know. *I* don't want to be a slacker; I don't think anybody else really does. It's like we all sort of respect each other; we don't really want to like, lag behind.

In other similar courses that the LEAD Center has studied in which groups were assigned, group dynamics problems appeared to be more common. One of the reasons might have been that, because they chose their own groups, students in this course considered it their responsibility and prerogative to make necessary adjustments in their groups according to the group dynamics and, in some cases, took it upon themselves to do so. For instance, one student who felt that the other members of her lab group generally were not well prepared for the experiments decided to join another small lab group which she felt was more serious about their work. She indicated that, although this was awkward, her second lab group was much more effective and on task.

Another reason why students may have taken their groupwork responsibilities seriously, is that the course assignments and exams were designed to be highly interrelated. As discussed in the student interview excerpt below, students were motivated to truly *understand* the problem sets even if they did them in a group (and thus had the opportunity to simply listen in and get an acceptable answer), because they knew that their understanding of the problem sets would be crucial to doing well on the exams.

R: [In my group, on the problem sets] people will get the answer, and then you'll break down the answer and be like, "How did you come up with that?" Then everyone will explain it to each other, like how and why we got that answer. I don't know about the other groups, but our group is pretty good about that. Like it's pretty much like, I don't know the answer very well and everyone else does. Or no one can come up with it, and I'll say something that triggers something in their heads and they're like, "Oh, that's what it is." Like even if I say something when I

> don't even know what I'm talking about, like, "Oh maybe it's this," and they'll be like "Oh yeah, it is this, because of this and that." And I'll be like, "Woo Hoo! Who came up with that?" And then so that everyone can understand, we usually talk about it for a while.
>
> I: Well, do you have any idea why [that is]? You know, sometimes the goal might just be to get the right answers, but it seems like the goal in your group is to understand. Do you have any idea why that's the goal?
>
> R: Just because like the exams are essays. If you don't understand while you're doing the stuff, and then you get the essay exam, and it's like all the stuff you've worked on…. And so if you understood it then, when you study it like brings everything back when you go into the exam. So, when they ask you questions related to that lab or that problem set, you like went over that problem set, and [you can say,] "This is why." And you understand what happened then, and you can act knowledgeable, and write stuff down on the exam, and actually know what you're talking about.

The following student quote makes a similar point.

> You can't get around [really doing the problem sets]…you can't blow it off…because the exams require a complete understanding of the material….So, you have to know what's going on…And a lot of times, to understand the questions in the first place, you have to understand the material.

One problem students discussed regarding groupwork was that it was difficult to make the transition from working as a group on problem sets to working alone on the exams.

3.2.1.4. Shifting roles: de-centering of instructors and new TA roles

3.2.1.4.1. Other students became important learning resources, thus reducing the centrality of the instructors in the student learning process

Consistent with the survey data, overall, students indicated that other students were very important for their learning in this course. When asked to rank the importance of other students, the TA, and the professor, it became clear that although the TA and professor were important, the other students were equally, if not more, important. Consistent with our findings from other courses which were designed to be student focused and utilized active learning, the instructors appeared to be de-centered in the students' learning process. They were still extremely important in terms of laying out the material to be tackled and guiding students in their understanding, but the interviews suggest that, for many students, a significant portion of their learning took place in their discussions with other students.

3.2.1.4.2. Two primary roles for TAs

The role of the TA in the TOA 104 course differed considerably from the role of the TA in a more traditional large lecture general chemistry course. The key differences were in the following two roles: 1) to help students understand the basic chemistry, apart from the real-world applications, and 2) to act as guides-on-the-side and stimulate the students' thought processes.

The first role above was carried out largely in discussion section. The more traditional role for TAs in discussion is to focus largely on helping students work on their homework, running discussion in a question-answer format in which TAs, for the most part, work problems on the board. By contrast, in this course the TAs engaged in a number of different types of activities during discussion largely aimed at helping the students understand the basic chemistry concepts which were addressed in lecture. Several TAs indicated that they rarely worked on homework problems during discussion but dealt directly with the lecture content instead. (This was, in part, a function of the fact that there were workshops twice a week designated for helping students with the assignments.) Students indicated that often their TA was crucial to their understanding of lecture, because whereas the professor provided the "big picture" and often introduced the concepts, the TA helped them develop a basic understanding of the concepts apart from the "real world" application. In most cases, the lecture and the discussion sections worked together as a system to give students two different types of understanding of the material.

> I: OK. So what about discussion section? Can you describe what that's like? What do you do, what do the other students do, what does the TA do?
>
> R: Discussion's great. We get together and, it's usually like, it's pretty focused in lecture, but then it will be even more focused in discussion…[For example, where the lecturer will] take just one concept, [the TA will] take just one example of that concept, to like, really explore. And s/he'll write a quiz on it, so it will kind of confirm what we already learned…
>
> I: OK. And when you say s/he takes specific examples, that's usually related to some real world concept or is it related to sort of just--
>
> R: It's just basic chemistry.
>
> I: OK. And what do you think of that approach? Last year I interviewed people on this course and that seemed to be the way it happened, that in lecture he talks about the concept, but he also talks about the real world connections. And in discussion it's stripped down to the concept. So I'm just wondering what you think the benefit of that is.
>
> R: I think it's great, because that way you get both. You get the connections to the real world, and you also get the application, but then you make sure you know the concept so you can apply it! So it's like he introduces it, "These are the

possibilities." And then in discussion, you sort of dissect that and say, "This is why."

****

R: I feel I learn more in discussion than I probably do in lecture.

I: OK, and you learn more because of the small group?

R: Well, the small group and the way that s/he goes over the stuff. S/he has more time to do a step-by-step process. S/he's not really applying it like in lecture. In lecture we will talk about HIV proteins and whatever, and in discussion we're just going over the general [concept].

Most TAs attempted to foster active learning during discussion. While a few TAs indicated that they felt successful at this and often had true "discussions" about chemistry with their students during discussion section, several other TAs indicated that they often felt forced into the role of lecturer when students came unprepared to discussion and/or were reticent to participate. Also, students whose TAs did not focus on the lecture material in either a facilitator or lecturer role but instead asked them to work in groups on problems, felt they were missing something in discussion because they had little time to get answers to their questions about lecture.

The other new role was to act in a "guide-on-the-side capacity"--not providing full answers but assisting students in answering their own questions. TAs took on this role mostly during workshops and labs. Although students often indicated that this was frustrating, they also tended to say that it challenged them to think more deeply about the material. The evaluators believe that this may have been another reason why students became central to student learning in this course--because students could not rely on TAs for easy answers relating to their assignments.

Students' noncommittal response to this approach may also have been a function of the fact that the students and the TAs described differences in the way that particular TAs interpreted and enacted this new role. (Because students could attend any TAs' workshop, they were exposed to multiple TAs.) Some instructors seemed to take quite literally the professor's suggestion to not given students easy answers, and were perceived as rather withholding by the students. Other TAs gave hints, and when students became completely frustrated, gave the students considerably more help. The latter type were more appreciated by the students who spoke of different styles. (See section 3.2.2.7. "Overall effects of TAs" for more on this issue).

3.2.2. Impact of Particular Course Elements on the Student Experience

3.2.2.1. Lecture

The lecture and the assignments worked hand-in-hand to stress the connections between chemistry and the real-world. It was during lecture that students first became exposed to the real-world topics around which the course was centered. Because of the centrality of the lecture to this new approach, many of the overall themes discussed in Section 3.2.1.1. ("Perceived effects of innovative approach to chemistry") are integrally linked to the students' reactions to lecture. Therefore, in the following discussion about lecture, we present only minimal information on students' overall reactions and focus more on their reactions to specific elements within lecture.

Overall, student interviews and survey data indicate that the lectures were considered effective in helping students learn the course material. Students found them interesting and informative.

> I think the lecture helps a lot in grasping the concepts. Especially I think, because I had my class last semester where lecture was pretty much straight out of the book, and so if I didn't feel like going to lecture, I could just read the book. And if I studied only from the book, I could get a good grade. Here, he actually takes his stuff from the book in his lectures, and then he actually shows you how to apply it. I think his lectures are very helpful.

The evaluators observe that in considering the students' generally positive assessment of the value of lecture, it is important to note that it is likely that with 3 to 5 ConcepTests a period, no period of actual lecturing lasted more than 15-20 minutes. This is important because it accords with a substantial body of research on the need to respond to the brevity of attention span for most students during lectures.[14]

Although lecture was viewed generally positively, several students indicated in their interviews that often they did not fully understand the chemistry concepts from having attended lecture and related that it was necessary to spend additional time focusing on the concepts in isolation from the application either during discussion sections or in discussions with classmates. In the following interview a student indicates that for him/her it would have been easier to understand the applications if s/he first understood the chemical concepts. His/her words also suggest that the pace of the lecture was a bit fast.

> R: I appreciate what's going on with when Professor [X] uses a lot of real life type examples, it's just sometimes it gets a little frustrating because he spends a good deal of the period on presenting real life examples, but yet sometimes the real key points and the real key concepts are just kind of-- how to put it?--he'll write it out on the board or speak through it real fast and then just go on with more like applied examples. And sometimes, I know like some people will learn easier if they hear an example you know and that, it applies to me a lot too, it's just that sometimes it seems like, I kind of wish that he would slow down and make sure

[14] For a review of the research on this topic, see Lion F. Gardiner's Redesigning Higher Education: Producing Dramatic Gains in Student Learning, " ASHE-ERIC Higher Education Report No. 7, 1994, pp. 37-55.

the fundamental concept was understood before he went on to more applied--

I: You mean like the commonality between all the examples?

R: Yeah. It just seems like sometimes the concepts are breezed through real fast, you know…And sometimes it feels like you're trying to catch with the conceptual understanding to be able to understand the examples.

3.2.2.1.1. ConcepTests

Students discussed that the lectures were highly interactive because of the use of what the professor called ConcepTests. They related that considerable time during each lecture was devoted to students answering questions posed by the professor and discussing (in pairs or small groups) the answers to questions which the students found particularly challenging. Most interviewees indicated that this method kept their attention and challenged them to really think about the lecture material during lecture rather than "tuning out" and waiting until later to try to understand.

I: So, any other comments on the stopping the lecture and--

R: Well I liked the fact that he gives us time to turn around and ask other people what they think, because sometimes if you're just sitting there like trying to interpret the board on your own, if it doesn't make sense to you, it just doesn't make to sense to you, you know. You can't stop lecture by yourself all the time, you know. I think it kind of helps that everyone's probably seeing something on the board a little bit differently, and if you can kind of see it the way that they're seeing it, it helps.

****

I like that in lecture, they'll be that interaction. Instead of just talking at you, he's more like talking with you. So it keeps you more engaged…You don't float off as much in lecture…It's easy in any lecture, I think, to sort of be watching the instructor writing on the board, and thinking about [something else]…But [with the ConcepTests] if you think about it, maybe you did get it wrong, and "Well, it is this," and talk about why. And actually it's kind of like being in one of those little groups again. There's two guys behind me that I know, and two guys over here, and this guy in front…And we go back and forth for a while. And if I just have part of it, but I don't really get another part, well he knows that part.

****

We're often asked to confer with your neighbor. Like he poses questions and you know says, "What's the answer to this?" And if we all don't know the answer, we get to talk to our neighbor and discuss it. It works. It gets us involved. Some

> people wouldn't be involved at every type of the lecture, I mean the statistics say that, you know, at any given time, fifty percent of the people are thinking about who knows what. So yeah, it does keep people on the ball, involved in lecture.

Some of these same students also stressed that it was important that the correct answer be explained fully in case they did not understand it and had gotten the wrong answer.

> He does give me sufficient time to [think through the problem and answer it]…I think the time when that goes wrong is when everybody agrees that the answer is A, and someone will raise their hand and say so, and he says, "Good, next question." But he should say, "Good, and here's why, for the ten percent of the people that didn't know that that was the answer."

Although students made many positive comments about the ConcepTests, many of the interviewees also expressed some ambivalence about the value of these exercises. They wondered whether this was the best way for the limited lecture time to be spent, as it meant that there was less time for the course professor to simply profess. In other words, they viewed the use of ConcepTests as a trade-off. Part of this equation was that, at times, students did not use the time allotted to discuss chemistry, but chatted about unrelated issues instead.

> In lecture he asks questions. And then he asks people to vote, and like if most of the people don't vote, he'll tell people to talk to their neighbors and discuss it for a couple minutes, and then he'll come back and ask us again…[And] I think it works to a point. Because some people will discuss it, but then some people will discuss it and then some others say. "What did you do last night?" So I think it works to a point, but sometimes people don't really take the time to discuss the question…Some people are just talking amongst themselves.

Some students were also ambivalent about the value of discussing the questions with other students during lecture, preferring to listen to an expert rather than discuss the questions with another student who might just as uncertain as themselves. The evaluator's believe that, in part, the issue here is that students were undergoing an adjustment to this new type of lecture and that they felt somewhat reluctant to break out of the traditionally passive student mode and participate, even if they suspected that this would be beneficial to their learning.

3.2.2.1.2. Demonstrations

In their interviews, students made few mentions of the lecture demonstrations. One student who did mention them indicated that the frequent demonstrations by the visiting instructor were highly effective.

3.2.2.1.3. Problem sets

Students emphasized the role of the problem sets in their learning for this course. As noted above, most reported that they tended to work with other students of their own choosing on these assignments and indicated that the time spent doing this was where some of the "real learning" took place. They said that, for the most part, solving the problems required them to draw upon multiple viewpoints and that the questions necessitated that they apply and integrate multiple concepts in the context of a real world problem. They felt that the problem sets were quite challenging. In fact, for some students the problem sets in the latter half of the course were considered too challenging. One of the challenging aspects of the problem sets was understanding what the question was asking and this was often where TA assistance was most necessary and useful.

3.2.2.1.4. Exams

The exams were considered quite challenging, as they consisted of essay questions which required students to apply their knowledge from lecture and lab material. As previously discussed, the students who were interviewed after the second exam perceived that the difficulty of the second exam far exceeded that of the first exam and that the second exam was less relevant to the substance of the preceding assignments. In addition, some students indicated that they did not feel confident that if they studied for an exam they would do well on it. (See 3.2.1.2. Logistical and calibration-related difficulties for more.) Another point discussed by students was that it was difficult to go from working on the problem sets in groups to completing the exams individually.

3.2.2.1.5. The textbook

In general, students expressed that the text was not as useful as the course text had been in science courses they had previously taken. One of the reasons for this, they explained, was that because the course professor was using a thematic approach, he did not present the material in tightly packaged units, the way most textbooks are written. Therefore, when the students used the text, they often had to flip from one section to another to find all of the concepts that were being addressed at any given time. None of the interviewees expressed that they were upset about this difference in the type and frequency of use of the textbook.

3.2.2.1.6. Expectations sheets

Students did not often mention the expectations sheets in their interviews. Based on interview data it would appear that these sheets did not play a large role in the students' experience in the course. This would be a reasonable outcome for an aspect of the class which was rather small in the grand scheme of things. One student did mention that she felt that sometimes the expectations sheets were too general and did not focus enough on the bottomline expectations, such as what would be on the exam.

> Sometimes [the expectations sheets] are helpful. Sometimes they are not. Like the most recent expectations for the test basically said know everything we ever

talked about. Some of them have helped. They give study problems, they say, "Oh, don't forget to focus on this idea." And they can be really helpful. But, then again, he can also expect you--I mean if you look at his expectations sheet for the test and what he actually tested us on, probably like a tenth of it. Like I understand learning what we're not tested on also, but to such a degree it was absurd…like he gave us expectations like he was kind of narrowing things down for us, which it wasn't, and then he tests us on like a tenth of it, so he should have just said, "Learn it all, and I'll test you on some of it."

3.2.2.2. Discussion--Varies by TA

As previously discussed, the TAs primarily dealt with lecture material during discussion and tended not to do homework problems during this time. (See Section 3.2.1.4. Shifting roles.) Although virtually all of the student interviewees expressed that their discussion sections were quite valuable, their comments and the survey data indicate that the students' perceptions of the value of the discussion sections varied considerably depending on the TA and the way the TA structured this time. Because this study was limited in scope, allowing only 1-3 student interviewees per TA, it is difficult to ascertain whether or not the differences in TA approach were the reason why certain discussion sections were more highly valued. We can draw tentative conclusions, however. It seems that TAs who were most valued tended to anticipate the difficulties students would have with the lecture material and discuss these difficult areas with students, providing sufficient time for "question and answer." In this way, they were providing a type of "scaffolding" that the students needed, both to successfully adjust to the TOA methods and to grasp the chemistry concepts. Conversely, it appeared that students whose TAs frequently asked them to engage in groupwork perceived their discussion sections as less valuable because they felt they lacked time to ask questions and get explanations from the TA. The following student interview excerpts illustrates this last point.

R: In all of my other discussion sections [in the past], it's always been, they'll take key concepts from lecture and just kind of go through them in a more step-by-step manner. In our discussion we come in and we're given a group exercise worksheet, s/he just hands them out to everyone, and then you turn around by your neighbor or whatever and try to figure them out.

I: Oh, so they're like, they're like problems out of the book or similar problems?

R: Yeah, kind of like that. And then you just try to figure them out…, and the TA kind of walks around in case you've got a problem. But after like 20 or 25 minutes, you know s/he kind of stops and goes through the answers and then s/he gives us a quiz and that's kind of it.

I: So if you have questions about concepts or whatever, do you have time to get that answered? Or is it just pretty much--?

> R: I guess that's kind of frustrating for me is, a lot of times the, if I were to have like a big question, or if I were not completely sure of the lab, the way that the discussion is structured, there really isn't any time for it. Because for a good deal of the time, you're working on this group discussion thing, or the group exercise, and then you know as soon as you're done with it, s/he explains it and then hands out the quiz, and the hour's almost over.

It also appeared that discussion sections in which the TAs followed the lectures less closely were perceived as less valuable.

Quizzes

Although the survey data indicated that students found the quizzes to be one of the most positive learning activities in this course, the interview data was more equivocal. It seems that some students found the quizzes beneficial because they were frequent (every discussion period) and designed to test comprehension of details. Having quizzes during each discussion meant that students had the incentive to learn during real time--during discussion and lecture--and could get timely feedback on whether or not they were understanding the basics.

> R: …Our weekly quizzes are great, they get people to class, they're not too tough, they emphasize things that are important….[In discussion] we go over problems that are like what he goes over in lecture, to reinforce that, and then we apply them immediately to our quiz and see if we can regurgitate them. The quizzes are more mechanical than [the rest of the assignments]…
>
> I: You mean like solve an equation or something like that?
>
> R: Right, which is something that's contrary to the exams, but I think it's part of the detail that we need to compliment the big picture.

Some students expressed, however, that they would have liked more time to study the quiz material, rather than taking a quiz on something they had just heard during lecture and discussion.

> R: In discussion s/he goes over, it's usually the kind of stuff we discussed in lecture, and we're just reviewing it. S/he gives us some problems, and then at the end s/he gives us a quiz, which is kind of hard, 'cause the quiz is on the stuff s/he just told us about usually-
>
> I: Oh really?
>
> R: -so I sometimes find that hard, cause you haven't had time to go over it again, what s/e just told you…I'd rather s/he quizzed us on the stuff we went over the previous time, than what we've just discussed.

Also, a few students felt that because the quizzes were worth so few points there was little incentive to actually study for them. One TA made a similar comment. S/he also indicated that the quizzes did not seem to act as a strong incentive to attend discussion, reporting that the attendance in his/her section went down after the point value of the quizzes was announced.

3.2.2.3. Lab Experiments and Integrated Lab Reports (ILRs)

As in the survey data, the student interview data suggests that overall the lab, although considered valuable, was perceived as less beneficial to student learning than the other course elements. We will first discuss the ILRs.

The first ILR was viewed as quite valuable for learning, because it required students to draw upon their notes and knowledge from a series of labs and apply this to a relevant situation. (Note: all of the students were interviewed before the second ILR was due.) In the following excerpt from a TA interview, the TA discusses the learning value of the ILRs an describes these assignments.

> The integrated lab reports, I would say, they get a lot more out of. Because again, they're doing this vocabulary thing, this chemical literacy thing…It's all writing, basically. It's a paper that they write…And the last one had one calculation. And it was sort of a short thing. And so mostly, they would just describe the chemical content, and say how it related to the lab…And how the lab related to this new problem…The integrated lab report introduces this new thing to them, and says, you know, "Why is this the case," or "How could this be the case," or "How could you explain these things, knowing what you know from lecture and lab?"…So I mean, it does a very good job of tying things together, and in just reinforcing concepts that are from the lecture. So I think part of the gain is that they get to see stuff, again, that they did in lab. But I think predominantly it's that they get to explain stuff that they've heard in lecture.

Student interviewees viewed the ILRs similarly, as illustrated in the following student quotes.

> A lot of the labs are similar [to ones we did in 103]. I think the most that we get out of them is when we do the integrated lab reports, and we relate the procedure that we did to [the questions on the ILR]. And that helps you understand, because you're working with a group I think, probably, it helps you understand…You have to write a research proposal about something, you have to explain, you know, how the reaction works, how your procedures fit the goal/desire, whatever. And what types of results you expect to see. So, it takes a lot of understanding, of a lot of things…[You have to] understand, you know, what's going on.

****

> Labs in general, they seem kind of like recipes, and [afterward] we're like, "OK?" …But then, it's kind of like, [the integrated lab report] gives you a problem when you have to use stuff from [lab to answer] it…Like this time [the idea was that we] worked for an agricultural company. And we had to find a compound that would keep iron from being transported into [an aqueous solution]... So, we had to figure out which of these compounds would do it, and why, and you know, we had to do certain things, and then, like, at the end it said, "Now you have to test this. You have to find ways to separate the fatty and the aqueous parts of it. And that [part] was like one of the labs we did, and I didn't really think about it when I did it. But when I went back and looked at it and I had to talk about it in this report, I had to make myself understand it, sort of. And then we had to measure the amount of iron in the aqueous solution…

Several students also made positive comments about the value of the hypothesis-testing experiments for which they had to design their own procedures.

> R: Some of the labs, like the ones where we have to produce our own procedures. I think those are real interesting.
>
> I: Oh, that sounds interesting…Was the acid/base lab one of those?
>
> R: Yeah, the one where you had to react the metals…[I like it because], I guess it just makes you think more. Because the lab with a procedure, you just follow it…With these you have to think about what you're doing, and figure out what'll happen.

Although students indicated that they did eventually understand the chemistry behind the lab experiments primarily through engaging in the completion of the ILRs, it is important to note that they also frequently felt confused about the purpose behind the labs and did not think about the chemistry behind the labs while they were conducting the experiments. For many, their goal was simply to "get through, and get out" of lab. In the following interview excerpt a student discusses that he would have liked to have known more about the context of the labs while he was performing the experiments and to have been given more opportunities to exercise creativity during the labs.

> I: You were saying it was interesting to learn about LEDs [from the ILR], and--
>
> R: But it related mostly to one lab, and, I mean, it was stuff we did in lab, it kind of did relate to it, but it would be more interesting to have known that before the lab, instead of after lab. Because, I don't know, it's kind of the shock value that you get before the lab, like, "Hey this is [about that]!" …I just didn't like---when I was doing it [the actual experiment], I remembered it was kind of dumb, I thought.
>
> I: Earlier you said all the labs were cookbooks…--

R: Well, like, what you do is, it gives you a procedure, and you follow it, and it's so easy. I mean, you could be half asleep, which I am, and do it, so.

I: It doesn't really force you to think about the concepts, or think about the things you're learning?

R: It doesn't bring creativity into it, like, if you did something wrong in the lab, it could, like, give you a totally different answer. But if you never have to make your own choices during the lab, that's kind of the thing that I kind of miss…Even if the experiment was designed, and you had to make your own choices, that would be fun.

Several students and TAs suggested that many students held similar views of the lab experiments and had similar experiences with the ILRs.

Students and TAs also suggested that the grading structure for the lab component of the course was related to these less effective experiences. As described in the course description, the grading structure was as follows: 1) students were required to complete the lab portion of the class in order to pass, 2) students received up to 2 points for completing each lab experiment and filling out a brief lab report, 3) a few times a semester students completed an ILR which combined concepts and data from multiple lab experiments. Students and TAs suggested that because students did not have to complete full lab reports for each lab and generally received their 2 points for the brief lab reports as a matter of course, they were even more inclined than usual to work quickly to leave lab early and put less thought and effort into the experiments.

R: Well that's another thing [in this course] to get used to too. Last semester we were always required to have a pretty extensive pre-lab in the beginning and then have like any kind of procedure you'll know if you need anything, all written out before you even come. And we're probably supposed to do a bunch of that this time, but, it doesn't--I guess because like last semester every lab was worth, I think it was ten points, or something, and this semester it's like two points for a lab,

I: It doesn't count as much?

R: Yeah. Sometimes, you know, it's good that he puts the requirement that if you don't come to a lab you could fail the class, because otherwise, you know, some people don't see spending three hours in lab for two points…it would kind of seem to me like last semester if you always handed the labs in to the TAs and then they gave it back like a week later with comments on it and corrections or whatever. And the thing that kind of gets me about having it only worth two points, and you just show it to the TA, and they check off whether it's one or two points, and then you get it back, and you need this info for a big thirty point integrated lab report later, is that, it seems like when the labs are worth more, once you hand it in, the TAs will take a good look at it, and if you screwed up on something or you didn't

understand something, they'll make note of it, but [it's not that way here]…

As noted earlier, the interviewees also indicated that there were some problems, especially during the second half of the semester, regarding coordination between lab and lecture, with lecture lagging behind the labs. In addition, at times when the coordination might have been more close, some student interviewees related that because their lab period was early in the week, sometimes important information about the lab which the professor gave in lecture came too late for it to be beneficial to them. Another factor discussed by students was that not all TAs reviewed the lab thoroughly prior to the students conducting the experiment. In any case, when students felt that they had little information on the concepts addressed by the experiments before they performed them, they felt less able to understand the concepts behind the experiments.

I: How well are the labs connected to what your talking about in lecture?

R: They are very connected except the big problem I have with them is that they are connected about a week before, like we'll do a lab and then it's like we start learning it [the concepts] after we've had it in lab. I have a lab on Wednesday morning, and usually then on Wednesday in lecture he'll present the idea we just did, and we'll actually kind of grasp it by next week, which well, I think the lab would be most effective and best at reinforcing the ideas we just learned. Instead of having that Wednesday right before we learn it, do it as a culmination after we learn that idea. I think that would be a lot more effective.

****

R: …There are some times when it seems like maybe we didn't go through the concept that's in the lab yet in lecture. So it's kind of hard to design your own experiments on it, do you know what I mean?… There was one lab, I don't know if it was one where we had to design our own lab, but I don't think it was a concept that we learned until like a week or two later…you know I wasn't sure exactly--

I: What you were supposed to be getting out of the lab?

R: Yeah, yeah. {Laugh} I looked at the lab report, I was like, "I have no idea what's going on."

Another difficulty which the students encountered was that while some lab experiments went smoothly, at least one lab, which was being used for the first time, did not go as planned, which frustrated the students.

Regardless of these problems it is important to note that students still rated the learning value of the labs and the ILRs fairly highly on the student survey, and most interviewees indicated that because of the ILRs they did eventually learn the concepts behind the labs.

3.2.2.3.1. UW ChemPages

Only one student interviewee mentioned using the UW ChemPages. This student found this to be a very helpful resource for the lab experiments.

3.2.2.3.2. Lab partners

Students interviewees discussed few difficulties with their lab partners and tended to relate that their group worked well together. In one instance, where the interviewee felt that her lab partners were not well prepared for most experiments, the student found new lab partners with whom she felt more comfortable.

3.2.2.4. Workshops

Most of the student interviewees had attended one or more the optional workshops. Importantly the interviewees who had not attended indicated that they had not done so due to scheduling conflicts, not lack of interest.) For the most part, students found them very helpful for getting over their hurdles on problem sets and ILRs. Students indicated that they either went to the workshops with their regular (informal) group or that they simply joined a small group of other students when they arrived.

While the students worked primarily with other students in small groups during workshops, they received valuable assistance from the TAs. Virtually all of the students indicated that the TAs' approach at the workshops was to guide the students by giving them hints to further their thinking, rather than taking them through a step-by-step solution to the problems.

> I: And what kind of role does the TA take during the workshops, sort of helping you?
>
> R: [S/he] kind of just looks [around]. You have to kind of get their attention too, you know, and they'll come over and if like, maybe two other people already asked that question, they'll be like, "OK, you guys want me to go over number three with you?," because they had talked about it before.
>
> I: OK. So when you ask questions, what sort of approach -- do they explain the answer in detail, do they give you hints? What sort of approach --
>
> R: [S/he] doesn't really focus on the answer so much as the question. It's more like you study what the question's asking.
>
> I: The actual problem set question?
>
> R: Yes, the actual problem set question. Like, "Well what does that mean?" So it

is sort of a hint, and sort of a clear explanation of the question.

****

The workshops are nice too. You need the TA there to help you knock out the problem set that's given because inevitably there's going to be a place where you get stuck. TAs are going to help you, they're not going to give you an answer, but they'll help you along - they are helpful. They're really nice to take your group in and find some questions off of them. For both the lab reports and the problem sets.

****

…We started going [to the workshops because]…the TAs have that background knowledge to understand. A lot of times we don't even understand the questions [the professor is] trying to ask us. They can break down the questions, say, "OK, here's what you need to be looking at," instead of us being at home for hours and hours going off on tangents having nothing to do with it. They'll tell you, "You're going off," or "You're way off." It's not like they're making it easier, they're just, a lot of times we just don't know what we're looking for…

While most thought this valuable because it challenged them to think more deeply, a few felt frustrated by this approach. Some students noted that TAs differed in how helpful they were. In the beginning of the semester there were some problems with students believing that the TAs had given them misinformation, because two TAs gave varying (and seemingly contradictory) viewpoints on the same issue. At least one TA felt, however, that this was simply a matter of the student not understanding that the problems were multi-dimensional and could have more than one viable solution.

Several students suggested that the workshops be offered more often or that there be more TAs at each workshop. These suggestions were based on the fact that some workshops were quite crowded and it was difficult for the TAs to work with all of the students who needed assistance in these cases.

The thing is usually a bunch of us will get together on weekends and go through [the assignment] and get as much done as we possibly can, and then there's usually like, maybe like 2e and 3d you know that we just can't get, and then we come to the workshops and try to figure them out. And then you know, it's kind of frustrating if you sit there for two hours for two little pieces [because there are so many students there], you know?

3.2.2.5. Grading

Several students indicated that it was evident that the course professor wanted them to succeed and the assessment structure reflected this. They also indicated that it was clear

that the professor really wanted them to learn from the course, not simply perform well on the assignments.

> When I talk to [the course professor], it seems like the biggest emphasis is always on--no matter how many times I'm concerned about how my grade is going--he's always asking if I'm learning things, you know. And I guess that, I really like that, you know?

****

> I: So what would you say [the course professor's] goals are for student learning in this course? What does he want you to get out of this?
>
> R: I think he wants us to actually know the stuff. I mean, I think it's good how he lets us take the exam back and re-work it. That just shows that he doesn't want, he doesn't want to say "Here's you chance, you blew it." you know? He wants to be like, "Look, this is what I test you on, and I really want you to know it, so take it home and try to understand the stuff." Like my roommate's in [a non-NT section of Chem 104] and [her course professor] wants her to fail. I feel so bad for her, because like the first average on the first test was 69. And he said that was too high. And he made it harder the next time. And then the average was like a 42! I felt so bad. They had multiple choice exam and each question was worth five points, and she got three questions wrong and she got a "B". He wants them to fail. I just don't know what I would do if I had a teacher like that. I feel so lucky that I have [Professor X] cause he actually wants us to learn the stuff. His whole purpose is not for us to fail. Not to show us "I'm so smart and you're so stupid!"

In addition, most students who were interviewed appreciated that the course was not graded on a curve, because this gave everyone an equal chance to succeed and it encouraged cooperation.

> I guess I think it helps [that the class is on an absolute scale], because a lot of times if there's like a really, a really rough problem you know, and I think with a curve, you know a curved scale where you know X amount are the only people that are going to get As, people are used to you know just kind of settling for a B or whatever. They aren't really going to always go the extra mile because they're used to getting the B, you know? But then when you take the curve off, I think everyone feels like they've got an equal shot at it.

Students who were interviewed prior to the second exam tended to indicate that they felt their current grades were an accurate reflection of how much they understood in the course. These students also expressed that the exams and the assignments were geared toward assessing their conceptual understanding and ability to apply their knowledge. A few of these students discussed that the assignments were designed to allow students to

show what they did know, unlike multiple choice exams which often only found the holes in their knowledge.

> I: How do you feel about the writing part of it?
>
> R: There's a lot of reasons I like it, and another reason I like it is because instead of just being graded on one thing, like the TAs are going to grade looking for *this* word, "Check," but instead it's like everything you know about the problem. So {pause} so you can say, "Yeah, I don't exactly know the sum answer to this question, but I know all *this* about it." But making that last leap, I'm not sure how these two things get to this point. But I know all this other stuff. So it's like in another situation where that same problem is not writing based, it would just be "Sorry -- you didn't get the answer." But in this case it's like you get the chance to really express all you know. I've been in a lot of situations -- I think everybody has -- where you come and you get into this discussion with your teacher, and you're like, "I got this and I knew this and this and this; this is what I *meant*." You know, "This is what I *meant*." And they're like, "Well, you didn't *show* that." So you get a lot more chance to show what you meant.

A few students did express some concern about the subjectivity of the grading. The felt that because the questions were open-ended and often had more than one right answer, it was difficult for instructors to grade them by objective criteria.

As previously discussed some students who were interviewed after the second exam expressed that they were not confident that if they prepared enough they would do well on the tests and that this differed from their previous experiences with science courses. (This finding was confirmed by student survey data.) The evaluators believe that although this appears to be contradictory with the view expressed in the above quote, this is due to the fact that the student quoted above was interviewed before the second exam and that the feeling of not being sure that studying enough would ensure strong performance was more prevalent after the second exam.

3.2.2.6. Student board of directors and the course professor visiting the labs

The course professor was perceived by many of the interviewees as quite concerned about the students' well-being and interested in student feedback. The fact that the course professor organized a Student Board of Directors and sometimes visited lab sections was seen as demonstrating this concern for students and was appreciated. A few students felt, however, that the course professor might be unduly influenced by a handful of students or was less concerned about some important feedback from the students than he should have been.

3.2.2.7. Overall effects of TA

Certain TAs consistently received the highest and lowest ratings by students on all of the survey questions which pertained to TAs and this pattern was supported by the interview data. Interview data indicated that there were significant differences in the ways TAs structured discussion section time which may have been contributed to this difference in ratings. (See Section 3.2.2.2. Discussion.) In addition, although all TAs were described as attempting to stimulate the students to think for themselves by not spoon-feeding the students, the interview data suggests that the TAs' approaches did differ considerably. For example, some TAs were considered better communicators in that they were better able to talk with the students on their level, rather than talking over their heads. Also, the TAs seemed to take different approaches to being a "guide-on-the-side." In the following student interview excerpt, these differences are discussed.

> R: [In the workshops], we'll just ask the TA to clarify something. They don't always help you, but you know, usually it's helpful. They'll just give you maybe an answer and have you think about it in a different way than you would normally think about it. So that helps.
>
> I: OK. Why do you think they don't give you answers?
>
> R: Most of them don't give us the answer, but some of them maybe have a better way of helping us get the answer. But I think they want you to figure out things for yourself….[which] is good. You know, it's probably better to have it, you figure it out yourself and you'll remember it better, or whatever. [But]…other TA's would be more helpful than our TA…[with some TAs, it's] like you'll raise a question and s/he'll get you to {pause}--not, like lead you to an answer, but--and some of them are like, "I can't really tell you anything." [And I think], "Then why are you here?" That's not going to help.

Another student discussed her frustration with her TA's approach and the way that she and her group members have attempted to get more direct answers from their TA.

> R: It's better now, but at the beginning of the semester, the TAs, they want you to learn on your own. So you go up and ask them a question and they are like, "No." And I'm like, "Just tell me what I'm doing here." So it's like you have to fight them to get an answer out of them cause they want you to come up with in on your own, which I can understand but still, it's [early] in the morning and we haven't talked about the lab. "Just tell me what's going on here."
>
> I: Tell me about that approach. How do they answer your question…?
>
> R: Well, they will kind of go in a round about way, like, "Think of it this way." And then they give you like, this different kind of scenario, and you'll be like, "OK?" And they'll be like, "Well, think of it this way." You know, they don't ever tell you if you are completely right. Like if your completely right they'll be like, "Yeah!," but if you're a little wrong they'll be like, "Well, think of this too." They

won't ever tell you exactly what they want you to think. So it's good that they make you think about it on your own, and if you come up with it then you're like "Wow! I came up with it." But if you don't then you get frustrated, and, but usually if I can't come up with it then someone in my group can…[So,] it gets frustrating at times, cause you have a question and you just want to be answered, but they just won't. Sometimes you just gotta wonder, but, it's fine as long as somebody in my group can figure out the answer. If nobody can we all just get really mad and we're like, "No. Just answer our question." And we just rag on [him/her] until [s/he] gives us something.

I: Really?

R: Well, what are you supposed to do, you know? [We just say,] "I haven't got a clue. Nobody has a clue!" We can usually get them.

The evaluators note that it may be too simple to attribute the differences among TA sections to just the TA approach. It may also be that the students in certain sections tended to be more resistant to the TA facilitator type role and had a stronger desire to be spoon-fed than other students. See, "Section 3.2.1.4. Shifting roles: de-centering of instructors and new TA roles" for more on this issue.

Foreign TAs

One pattern which emerged was that the foreign TAs as a group were consistently ranked lower than the non-foreign TAs. The evaluators believe it is possible that this trend reflects a combination of students' pre-conceived beliefs about the abilities of foreign TAs and actual communication and cultural differences exhibited by the TAs. We do not believe that this suggests that the foreign TAs were in fact less effective than the non-foreign TAs. However, we present this finding as it raises some important questions. The evaluators feel that it might be appropriate for the faculty member to be pro-active in addressing possible student biases in order to avoid hindrance to student learning which might arise from students' pre-conceptions about foreign TAs.

4. The TA Experience

At the beginning of the semester, TAs were asked to complete a survey about their incoming attitudes toward teaching and specific pedagogical approaches, including those to be used in TOA 104. The results of this survey were reported to the course professor shortly after survey return. However, because only 5 of the 8 TAs returned the survey, we do not rely on this data heavily for the analysis presented herein. This analysis relies primarily on the interviews conducted with 7 of the 8 TAs during March and April of 1997.

4.1. Overall Themes

All of the TAs who were interviewed indicated that their experience as a TA for TOA Chem 104 differed considerably from being a TA for other lower level chemistry courses. In this section we discuss some of the salient differences, focusing primarily on those that relate to the research questions articulated at the beginning of this report.

In general, the TAs felt positively about TAing for this course, feeling that the professor's approach was beneficial for the students and that their role in instructing the students was an important one. The TAs did, however, discuss many challenges and problems, and these will be presented throughout this section.

4.1.1. Attitudes toward teaching and the TOA 104 course features

Both in the beginning of semester TA survey and in their interviews, as a group the TAs for this course indicated strong interest in teaching. A few of the TAs expressed interest in pursuing teaching as part of their post-graduate career.

In addition, their incoming attitudes toward the innovations used in the TOA 104 (as expressed in the beginning-of-semester surveys) were mostly positive. In fact, at least two of the TAs had requested to teach with the course professor, because of his pedagogical innovations. As a group, they expressed that, for the most part, they anticipated that the groupwork and the conceptual, topic-oriented approach would be good for the students' learning processes. Several TAs expressed specific concerns about implementation, but their overall attitudes toward the potential of the general approach was positive.

During their mid-semester interviews, most TAs indicated that they felt positively about the major course features. Most pointed out that there were significant difficulties in terms of smooth implementation of each of these components, but remained positive about the approach overall. The following TA quotes are about the positive aspects of the topic-oriented approach.

> Well, right now, after pretty much breaking some ground in the course, I guess the

way it's pretty much taught, bringing out concepts more than the mathematical part, is what should be done in general in chemistry…The reason why is they pretty much bring actual topics, and they just, you know, go through the basic topics, and try to explain the entire picture. And that would give them at least, you know, a better view of what's going on. Pretty much an example of that is right now, for the past couple of weeks we're talking about protein and then we're relating that to kinetics, and then we're relating that to protein and protein to HIV…I would encourage everybody, especially the 103 professors, …to try to teach it this way.

****

Sometimes I've been hesitant because I thought, well, you know, "They're not learning these certain concepts." And, you know, "I learned that, and I thought it was important." But then if I think about the stuff that they need to know for organic chemistry, and that they're definitely learning. Stuff that they would need for a higher lever physical chemistry class they might not be learning, but I don't think that's important. Because I mean I think part of the problem with introductory chemistry is it gets taught at this higher level, and people get really turned off by chemistry--the general population. If you say---now when I told people that I was a chemistry major, they cringed. You know, [they said], "That's so horrible. It's boring." And it's not. And so I think if you make introductory chemistry process more exciting, people who aren't going to end up in chemistry will still have a greater appreciation for it, and will know more. I mean [the course professor] teaches much more of everyday chemistry stuff [and] relates it to real world problems. So, I think students are thinking about what they see on a regular basis, so that they understand how these concepts that they are learning relate to the world. Where when I took chemistry I didn't learn that. I mean I learned all these chemical concepts, but I didn't learn the relationship though. I mean I didn't learn, "Oh, well now I can explain how acid rain works, and how that works." But when I was taking it, it was kind of a side thing. I learned those things through conversations with professors one on one or lab instructors, but it wasn't part of the course.

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I've been telling this to a lot of people who have actually asked me, including the general chemistry office. I said, "This is the future of chemistry teaching in this department, if we are able to actually glue this together, and convince people."

4.1.2. New TA roles associated with TOA Chem 104

During their interviews, TAs discussed that they played multiple roles as instructors for TOA 104. As in the following interview excerpts, the TAs tended to say that their roles for this course differed quite a bit from the traditional role of TA as "problem-solver."

> There seems to be a little bit more commitment involved in this teaching, because most other teachers, because I've had [several] semesters of TA experience, and with the typical science teachers, chemistry teachers, they generally lecture and give problems for students to do. TA's are more or less problem solving machines. They sit there at the board and go over these problems or concepts. So you never have to worry what to prepare, what to do. You just go in, and they ask you questions about problems. And you set it up with them, you discuss it with them. You can try to get them to talk while you're there, but most of the times, you're just going to do the problems. And if you don't do the problems, you get poor evaluations. If you *do* the problems with them, it kind of shows--your evaluations are better. So I don't know, after a while I just realized I didn't like teaching that style at all…

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> In a more standard course, …what I find myself doing more, is working problems. They get assigned a certain number of problems, and they are going to be expected to do these types of problems on an exam. And so students, if they have problems, sit there and ask, "How do I do this problem?…" In this course, what I find myself more doing, is just discussing chemistry, and just talking with them. I write on the board a lot less. And I talk, I describe something, I'll ask them a question and they'll respond to it. And then, if their response isn't quite right, I'll try to redescribe what I was just saying maybe in some other way.

Most of the TAs expressed that they had had to adjust to their new roles. In the following interview excerpt, a TA provides an over-arching comment about the nature of this adjustment.

> Because this is topic and concept oriented, and these answers are more open-ended, and [we're] describing the chemical concepts and things like that, it becomes harder to teach for them. It's harder for me to teach that too. I mean, even though I've taught [like this] before. You know, when everything's become more open-ended, and you've got choices to make, choices are harder than not having choices.

4.1.1.1. Clarifier of lecture (as opposed to problem solver)

As discussed in the students' experience section, an important TA role in this course was to clarify lecture. For example, some TAs spent considerable time helping students understand the chemistry concepts apart from the real-world examples through which were introduced in lecture. The following TA quote illustrates how and why this was necessary.

> I: What are the hardest things for the students to learn? Are there any big stumbling blocks that come up?
>
> R: Well I guess it's pretty much, the way this course is taught they pretty much ask you to learn a lot of small details, small concepts in a way, that will help them recognize the broader picture. Those sometimes they get right away, and sometimes they don't and I think it's because of the speed of the course…And I guess, this was my personal, when this HIV topic was brought up, there were a lot of concepts that I personally saw in organic chemistry as an undergrad, and they [didn't get them] right away. Even though it was brought up to them in the most simple way, some of them didn't get it. And that becomes at once a problem, but sometimes…a TA has to try to bring it into a simpler context, so they can understand it.

Another TA described his/her role as a "fine-tuner."

> I'm a fine-tuner. I go in, and after---The lecture is where they get the bulk of the material, or at least where the main direction of the course is given. And so, that's where all the topics are introduced, and that's where all the concepts are at least introduced. And my role, then, is to go in and to sort of make sure that the students understand those concepts, and are following along with the progress of the course. And so…I make sure that they understand what's going on. And when I say fine tune, you know, they'll have some sort of understanding, or when they first hear a concept they'll latch onto something. And my job is to make sure that it's the right thing.

TAs also discussed that in a few cases, they had the responsibility of introducing new concepts to students, because this material was not presented in lecture.

Because of the responsibility described above and the additional one of introducing new concepts, a few of the TAs indicated that they felt they had more responsibility as a TA for this course. Their feeling was that they played a more crucial role in student learning in comparison to their role in traditional courses.

> R: For this course, after the first staff meeting I knew that there was gonna need to be some extra effort on it, because most of the concepts are explained in class but some of them are left to the TAs to pretty much cover, not just to clarify stuff.
>
> I: So you see more responsibility for the TA's then in a traditional way of teaching

this kind of course?

R: I see that yeah…I think right now that I have a more important role compared to 103 because the lecture, I'm pretty much the next link in the chain, and even though some of them e-mail the professor with their questions and that, I'm pretty much the mediator.

4.1.1.2. Groupwork facilitator

As TAs were encouraged to use groupwork during discussions and required to stimulate small groupwork at the workshops, another new role was that of groupwork facilitator. Many of the TAs had little experience as either instructors or students using groupwork. Therefore, this required some adjustment. On their early semester surveys, several of the TAs mentioned that they would like more training in how to carry out this role. In their interviews, however, most mentioned few problems with group dynamics. In the following TA interview excerpt, a TA discusses how he dealt with problematic group dynamics in his lab section.

I: Have you had to deal with any problems in the groups?

R: No, they all seem to get along pretty well. Some groups are faster then others. Some groups tend to get distracted very easily, they are not focused on what they are doing. In one group, one of the members I think frustrates the other members a little bit, so I try to spend a little more time back at that end of the room…[This one student] has a very aggressive personality, he wants to put in his two cents all the time, he wants to be, he seems to want to be in it all the time, to ask all the questions, like if somebody has a question he'll run up and ask it first, and if they develop a group question, he's always the one to ask it. I think that causes some friction.

I: So how do you spend more time back there?

R: I think it's when they are trying to figure something out that they, it's not so much a discussion as an argument. So I try to spend more time there to be able to, sort of, be another entity in the discussion, and try to keep it at a lower level.

By contrast, one TA indicated that some of his/her students strongly resisted doing groupwork during discussion.

It took a while, the very first two weeks, for them to understand that the discussion was actually a *discussion*, not a TA being the problem machine, type of the thing. Then it took a while for them to try to work as groups. Even now, they have problems with things, small groups. They would prefer that the TA's do the problems for them…I usually come in with a worksheet for them to do, with 1, 2, 3, or 5 questions, depending on how hard they are. Usually the first question is

> really easy, general. Then the later problems are a little more difficult, and I ask them to work in groups of 3 and 4…Most of the time there is a group that always works well together, I don't know why, …but some of the guys they sit in the back in a straight line and they'll talk to one another, to the guy next to them, but…they won't even form little circles, because they say it's too much of a hassle…I told them to get in a circle at the very beginning, and said, "This is the last time I will ask you," and they will just kind of straggle back to the line…Usually well they can get half of them solved. I only give them about 10-15 minutes. If I let them have more than fifteen minutes, well the group, that is particularly these guys, they get bored after fifteen minutes. They'll start talking loudly, and then I know, "OK it's time to get back," because otherwise I lose control of the students.

It is important to note that the TA quoted above indicated that s/he often asked students to engage in groupwork toward the beginning of the period and left the question answer part for last. Students who experienced this approach indicated that they felt they did not have enough opportunity to clear up their confusion from lecture. *Evaluators' Viewpoint:* While there may be other causes for student resistance to groupwork in this TA's section, it may be that a concern over lack of time for questions about the lecture contributed to this situation.

4.1.1.3. Guide-on-the-side

A related role was that of "guide-on-the-side." TAs sought to stimulate students' thought processes rather than give them easy answers. Although all of the TAs who were interviewed related that they used this basic philosophical framework to guide their approach to helping students, their descriptions of just how they implemented this idea were slightly different. In addition, they indicated varying degrees of success with this approach, particularly with regards to the degree of student resistance they encountered.

Two of the TAs who felt fairly successful at this approach are quoted below describing their approaches.

> I: And when students have questions in lab, how do you tend to address their questions?
>
> R: Um, sometimes they are just procedural things, where they don't understand what to do next. Sometimes, for more conceptual things, I try to ask questions back instead of just explaining what is going on. Sometimes if they don't understand how to do a calculation, it's because they don't understand the concept behind it. And you fill those in, and they understand it then. So I try to ask them questions back… It works pretty well.
>
> I: So what happens when that doesn't work?

R: Well, I will try and lead them through. I give them these two options, and I ask them, "What do you think about this?" [And they say], "Well, I don't know." [And I say], "Well, you could either do this, this, or this. Which one would be the best thing to do?" I guide them through that way.

I: And are some students resistant to that? How do students tend to react to it?

R: Um, they don't seem to {pause]. Usually well, if somebody says, "Well I don't know, what do you think?," then I give them a few options, and they will pick one. So if I just try and draw stuff out of them, it happens.

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[The way I respond to students], really depends on the question. Sometimes you get the question: “What’s the answer?” And that’s a hard question to answer. And so what I generally try to do is to ask them the question back. And then they’ll say that they don’t understand it, and then you get to ask them, "What don’t you understand?" And then they’ll ask you another question, which is the question that you should have been answering in the first place. And so you just try to re-direct their question, to find out what is the concept that they’re not understanding, that’s not allowing them to do this problem. And then once you find what it is that they’re not understanding, then you can sort of redefine that concept, and sort of explain something to them. You know, explain the concept again, and then say, “Now how does that apply to this problem we’re looking at?” And then they’ll hopefully get it at that point, and say, “OK, well it’s related because of this." And you say, "Good.”…That’s what you try to do. And sometimes it works well, and sometimes it doesn’t.

Another TA, who indicated that s/he experienced quite a bit of resistance from students, described a more strict adherence to the policy of not giving easy answers to students.

R; I say that [the workshops are] a mixed bag, a mixed bag because even in that environment, actually, many students actually come with the idea that whoever is doing the workshop on that night is basically going to make a, a walk-through. And that’s not what we do. What we are going to do is provide them with some hints or ideas, general ideas of how you might want to proceed in solving this problem. But I’m not going to tell you what to do, because that’s completely unethical. And some students…feel frustrated. There were even some students that [said that]…some of the members of the staff were actually giving them wrong ideas. It’s not that we were giving them wrong ideas, it’s that we were not telling them the answers. But I’ve worked with many of the members of this staff, and I can tell you that they are very professional. So they were not wrong ideas whatsoever, it was actually, we were just, we can tell them, “Hey. That’s actually on the right track. That’s actually-- you’re thinking, and your thinking makes a lot of sense.” Then the --

I: Even if it’s not the right answer.

R: Yeah, the right answer, yes. I would tell to my students, “That’s actually, you’re on the right track, but you need to actually fine-tune some of the things, so I suggest that you find information on these, and information on that, and information on that.” And I think that’s just a sketch, and that’s actually appropriate to do. But the thing is, I’m not going to so much, I have students that say, “Is this right? Is this the correct answer?” And I say, “You know, for these things you might, there might actually be more than one answer.” And I’m not going to, and I tell them flat, “I’m not going to tell you the answer, because that’s completely unacceptable. What I will do, is I actually will help you to organize your thinking, so that you actually eventually get to an answer that makes sense.” That it might be different, or your explanation might be different from another student's because the approach you took is different, but there’s no right answer or wrong answer. And they don’t like that…[They assume] that there has to be one answer for everybody, and there has to be one right answer. I think it’s part of the culture, again. You see the way they say: “What is the answer? What is the value?” And I, sometimes I say “You know, the answer is really irrelevant. It’s very irrelevant, because the answer might be what: A sentence? Or it may be an answer, a numerical answer like 3.4 Mg per mil?” But you see, that’s irrelevant, because what’s really relevant is, "How do you get there?"

Evaluators' Viewpoint: It is difficult to draw firm conclusions about the differences in TAs' guide-on-the-side approaches and students' various reactions to them, because of the small number of TAs and students interviewed per TA. The course professor may want to explore this issue more fully during the next iteration of the course. Based on other LEAD Center studies involving similar pedagogical methods and the role of TAs, we have found that when asking students to take more responsibility for their learning and be active participants in the process, it is important for instructors to realize that they will have to struggle to find a balance between letting students flounder and giving students enough guidance and support that the students' frustration level remains tolerable. Those who have discussed this idea of balancing these two factors have indicated that this is one of the most challenging aspects of this new mode of instruction.

4.1.1.4. Cheerleader/Mediator

As discussed in the students' experience section, students had to adjust to the differences in the teaching style for Chem 104. Several of the TAs discussed that one of their roles was to help ease this adjustment by providing encouragement to their students.

> R: When I started, I had the feeling that there was a lot of tension because of the course. So I tried to make their lives simpler, like, "Don't worry about this"
>
> I: Was [the tension there] because they weren't sure what to expect?
>
> R: Yeah, that was pretty much it. It was because they were in this new type of course and they couldn't tell what was going to happen…
>
> **********
>
> I can see my students are giving a lot of effort, and sometimes you see their frustration. But [it's important that]…we actually…reinforce what they do. I say, "That was excellent. What you're doing, what all of you are doing," So you have to do a lot of verbal reinforcement, because sometimes they feel, "Hey. This is very alien to us." …[Sometimes it's important to think], "What do you do to…lower or diminish that sense of frustration?" And you say, "Nononono, it doesn't-- You're doing fine, because you are doing exactly what we're expecting you to do," which is engage this thing, which is like taking the bull by the horns…And, you know, he has actually presented them with a lot of things in which they have very little, or no background. And they have been able to actually engage, and do excellent work…And part of our duty of actually provoking enthusiasm, is actually reinforcing the students to say, "Hey! You are really doing a fine job here."

In addition, they indicated that because this was still an experimental course, and not all of the bugs had been successfully worked out, they played the role of mediator between students and the professor, making sure to communicate with the professor about any difficulties the students were having.

> And the other thing is just sort of a gauge for how students are doing, and you know, reporting that back to the professor. To make sure that, you know, students aren't having huge problems with anything. And if they are, to let him know. So that may be more time in lecture for him to spend on that, or it could be introduced in a different way, or something.

4.1.2.5. Grader of open-ended assignments

Another significant difference in the responsibilities of TAs in TOA Chem 104 vs. for traditional courses was with respect to the type of grading. Because all of the major assignments and exams were of a conceptual and more open-ended nature, the grading for these assignments required more understanding of the issues relating to the assignments and a new way of assigning points to a students' work. In traditional courses which involve primarily calculation-based assignments, the right answer is relatively easy to identify (although assigning partial credit may be more challenging). By contrast, in this course, there were sometimes multiple approaches to the same problem, all equally viable. Thus, the process of grading the assignments was more difficult and involved more judgment calls. Additional challenges with grading were due to the communication problems discussed below.

4.1.3. Communication problems

Most of the TAs discussed that there needed to be better communication among the instructors of this course, particularly with regards to the professor clearly communicating his expectations of the students and the TAs. Their comments suggested that there were three inter-related problems: 1) the lecturer's plans for lecture were sometimes unclear and sometimes changed, 2) the nature of the course made it difficult to clearly define expectations, and 3) the professor's approach was to attempt to reach decisions through discussion among the instructors, as opposed to making executive decisions.

4.1.3.1. The lecturer's plans often unclear or changed suddenly

The TAs indicated that although the instructors would discuss weekly plans at their staff meetings, the lecturer's plans were sometimes unclear or would change, such that during lecture he addressed topics that the TAs were not expecting or he was not able to do all he had planned. When the course professor's plans were unclear or changing it was difficult for the TAs to know what they were supposed to address during discussion. The following quotes illustrate this problem.

> Like, I've gone to lectures some days, and, you know, he'll just start lecturing, and we were like, "Wow, you know we didn't know he was going to talk about this today." You know, "Why didn't you clue us in?" …And it's not necessarily the nature of the course, it's just a matter of, that's one issue that I would like to see more…,well, just better communication. I mean, you know, looking at the TAs…[and saying], "Hey listen, this is what we're going to do."

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> I think right now the last couple of weeks it's been really hard with the class

because some place we lost communication with [the professor]. He was out of town for a week and then there was Spring Break. So there's been a lot of confusion about what he's going to cover and what he wants us to cover. And I know I've talked to several of the other TAs and they feel the same way, that we're kind of lost about what what's really important for these students to know. So what we should be stressing with discussion sections. They have an exam in two weeks so they're getting stressed out and we're kind of in the dark too. So that's been really hard…[The students feel they] need to know exactly what they need to know. Especially when the course is not being taught with…specific text book related things. You know, he doesn't follow the textbook. He gives them background pages to read, but he's not following the textbook…We're starting to get back on now, because he was here last week. But, the TA's I think were feeling a little bit lost, like, "What's going on?"

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I: You mentioned that [the professor] was interested in giving the TAs more freedom. Has that come about, or how do you see that?

R: Well, it seems to have happened…But, sometimes giving freedom seems to verge on lacking guidance. Sometimes it seems that we are not clear on, sometimes we start the week not quite sure of where the lectures are going to go. So it's hard to know [what to do in discussion.] If you have a discussion section, discussion sections are on alternate days, before or after lectures, sometimes….I'm not sure, where lecture is going to go. And like, I'm not quite sure what to teach in my discussion sections if we've already covered what we just covered in lecture.

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Occasionally what happens is because the labs will get ahead of the lecture [and the course professor] will tell us in the staff meeting, you know, "I'm going to do a short demonstration in lecture on Monday that will help with your lab this week." And the problem is though that he runs out of time in lecture and he doesn't get to that to get to that demonstration. So all the TA's have thought, "Well that's going to be covered in lecture. I don't need to talk about it in discussion." And then suddenly you have a lab that you haven't talked about in your discussion. So that's a problem.

Although at least one TA felt that the above problem was ameliorated by the expectation sheets put out by the professor, s/he still felt there was need for better communication among the instructors. Another TA felt that a contributing factor to the communication problems was that the course professor expected the TAs to communicate with the head TA about problems, rather than with him directly, and that this made the course professor inaccessible and inhibited free communication. Other TAs indicated that the course

professor appeared to be stretching himself too thin and because of this did not have the time to fully plan for the course and to communicate fully with the TAs.

4.1.3.2. The nature of the course made it difficult to define expectations, necessitating greater communication

As discussed in the following interview excerpt, the open-ended, conceptual nature of the assignments presented a challenge in terms of setting clear expectations for students.

> R: The problem I have with that class is that I think that there's lack of communication between the instructor and the TA's…I mean, the TA's, as a group, feel we don't know the set expectations for class, so that we know what to prepare the students for, or even, it would be nice to know ahead of time, of what would you like them to learn. What are the expected outcomes of this unit, …as far as, uh, I guess what problems would be a good way of assessing what kinds of things they would need to know. Although, you know, the examination and things are very, they're different because they're not like, "Solve this chemistry problem." It's more descriptive…You have to understand.
>
> I: You're supposed to exhibit your understanding.
>
> R: That's right.

His/her comments indicate the need for a higher level of communication among the instructors of a topic-oriented course.

4.1.3.3. The professor's approach was to attempt to reach decisions through discussions among the instructors, as opposed to making executive decisions

Most of the TAs expressed some frustration at the professor's insistence that they work together as a group to make decisions and create answer keys. They felt that this was one source of the confusion about expectations. As explained in the following quote, the confusion was due to the fact that the TAs had widely varying backgrounds, and thus it was difficult for them to come to an agreement on expectations.

> R: Sometimes the TA's don't exactly know [what is expected] themselves. Like, I'll give you an example. They get a problem set, which is actually fairly difficult for them. You know, they take a couple weeks to work on, and they bring together a lot of ideas from lecture, and lab, and discussion. And, if you're a graduate student in chemistry, you have different backgrounds in certain areas. You would answer a question like that, you know, you could answer it in a variety of different ways, you know, depending on your strength and weakness, and how in detail you would answer the question. You know, the level of
>
> I: So the questions aren't, by their nature, they aren't really sharply defined.

> R: That's right, [as to], "What are they looking for?" Right. So, you know, I've noticed differences between TA's, like, how they answer a particular question…And that goes back to [questions about discussion, like], "Well, what kind of detail are you going to talk to your students about this particular topic?"
>
> I: So you give, is there a wide variety of detail?
>
> R: I think that there is, from just talking to other TA's, I think that we're not as cohesive as he would like us to be…My opinion is, …there's just too much difference between what the TA's are doing, because they don't know, for sure, what the professor is expecting.

This issue was related to two structural factors. First, the instructor employed rotational grading, having one or more TAs grade a problem set or ILR for the entire lecture section. This meant that it was important for the TA(s) who graded the assignment and the other TAs who would be giving students guidance on the assignments to have a shared vision of the expectations. Secondly, during the TA meetings, half of the TAs worked together to solve the problems or develop answers to the ILR and create the answer keys, while the other half worked on the writing quiz questions. Thus, not all of the TAs shared in the process of setting the expectations, and therefore, may not have understood them clearly. The TA quoted above suggested that if one person, the professor, were setting the expectations, it would be more clear.

> I know he wants us to go through this experience, right, and so another group gets together and they write, like, suggested quiz questions for the week. And, basically it's one of those situations where we're looking at each other going, "If we're trying to figure out answers to this problem set, or something, or for this integrated lab, why doesn't he just tell us what he wants?" I mean, it's not like we don't know. As TA's, we've been teaching this stuff, and we're grad students, we know how to answer these questions. But, "Why don't you tell us directly what you're expecting the students to learn?"…I mean, I don't have a problem with him telling us what the answers are, and how he wants them answered. I mean, I don't feel like I'm missing out on the process, because, you know, I'm past that point where I need to have to participate in that to learn something I already know, or something…Well, an example is, they have this problem set due Friday, and this once person is grading the problem set. And, anyway, s/he came to me today and says, "Here, I have worked out the answers to the questions." Which is great. I'm glad so when we go to these workshops, we know what the answers are supposed to be. But these are his/her answers. I mean, s/he's going to grade it how s/he wants to grade it, and I didn't necessarily agree with how s/he expected, you know, what kind of answer that s/he wanted, but you know, that's just the way it is.

This is not to say that all of the TAs felt the time spent in TA meetings developing answer keys was wasted time. Some felt it was very valuable for understanding the problems and developing their abilities to assist students. However, all expressed some confusion over the expectations for students, and this, they felt was related to the professor's style of having TAs develop the expectations. See, "Section 4.2.1. TA meetings," for more on this issue.

4.1.4. Estimation of and reaction to time spent by TAs

The course professor made the following efforts to ensure that being a TA for this course was not more demanding than being a TA for another section of 104: 1) he reduced the amount of weekly grading through eliminating individual lab reports, opting for longer, more in-depth integrated lab reports a few times throughout the semester, 2) he employed rotational grading, whereby one or a few TAs would grade a particular assignment, and 3) he asked TAs to reduce their office hours in order to make up for attendance at the workshops. Still, most TAs indicated that being an instructor for this course took more time than TAing for other lower level chemistry courses. The one TA who put this statement into an hourly figure estimated that it required an additional 5 to 10 hours per week. However, some of the TAs tended to indicate that the *way* in which they spent their time as instructors for this course was somewhat more meaningful than in their past teaching experience. The following quotes illustrate this point.

> I enjoy teaching this way more, because again, I get to write on the chalkboard less, and I get to write equations less, and you know, X = Y and all that kind of algebra stuff which, you know, is OK, but I get to talk more…[And] I like doing that. And discuss things. And always more interesting. And so just on that level, yeah, I get something out of it. Or, I get more out of it than teaching some other way.

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> I think the labs, the emphasis he tried to place on doing the labs and getting something out of them instead of spending your time answering silly questions out of a lab book is better. And the fact that the TA's do not spend hours every week grading laboratory notebooks is a lot better. That has helped me a lot. Because I felt like that grading those lab write ups were a waste of time last semester.

We wish to stress that while most TAs stated that the course required more time, they did not indicate that this caused them significant difficulties managing their other responsibilities as graduate students.

One reason cited for the extra time was the more difficult and time-consuming grading associated with the conceptual and open-ended course assignments. So even though the professor had incorporated integrated lab reports, thereby eliminating weekly grading of individual lab reports, this did not completely balance out the workload. Another way that

time was spent was in the TA meetings and the workshops. The TAs were vague about the way in which the TA meetings and the workshops affected their workload. One difference which was mentioned was that while TOA TAs were required to spend less time in office hours, to balance the additional time in workshops and staff meetings, the trade-off may have resulted in more actual TOA work. This is because, in general, office hours are not well attended for both traditional and non-traditional courses. So, although TAs are required to be in their office during their scheduled office hours, they often are able to do their own work or other work for the course during this time because no students come to see them. This was not the case with the TA meetings and most workshops. During those times, the TAs were required to give their undivided attention. Therefore, although the official number of TOA-dedicated hours might have remained the same, the actual time spent focused on the course may have increased.

4.1.5. Benefits to TAs

Although it was not an issue which we raised as part of our interview protocol, TAs discussed several benefits they gained from being TAs for this course. Several TAs felt they were gaining invaluable teaching experience, valuing the opportunity to try the new pedagogical methods being employed by the professor. Other benefits mentioned were strengthened conceptual understanding, improved communication skills, and increased understanding of the "big picture" associated with general chemistry concepts.

4.1.6. TA training: departmental issues

In their beginning-of-semester surveys, the TAs indicated expressed several specific needs for additional training or information. These included facilitating groupwork in general, incorporating active learning in discussion, and speaking simply about complex things. In addition, one or more TAs wanted more knowledge of the students' Chem 103 background, practice in speaking English, and a high level of communication among the instructors of this course, including explicit information on the professor's learning objectives for students and plans for lecture.

Although TAs continued to express concern about the need for more communication among the instructors, on the whole, in their mid-semester interviews TAs tended not to say that they needed additional training to teach well in this course or in subsequent courses. When TAs pointed out that they had difficulties with certain aspects of teaching, they tended to indicate that the source of the problem was in the way students behaved or the course was structured, and did not express that they needed additional training to overcome these difficulties. One TA who did indicate that s/he wanted more training felt that the department should expand upon or provide follow-up on the standard TA training given to all TAs to include training on cooperative learning strategies.

Another TA discussed that although it was important to expand training for all instructors, there was a conflict of interest inherent in having graduate students as teaching assistants, because the primary goal of most graduate students was to get a degree.

> I think you need to actually train the staff, and the training program in the Department of Chemistry, …a lot of efforts are being made in order to actually train the supporting staff to actually be a part of this process. But we still have a long way to go here. And the reasons for that is, the first thing is that we have a duality in here. And part of the reality of this institution is that the students actually come here to--What? What's the main purpose? To get a degree. So if I came to grad school, to me teaching, or at least the way it's conveyed to them, is actually just [peripheral.] That's actually something that I would do, if you actually paid me some money to do it. But my priority is to get a Ph.D. So if I don't get a Ph.D.-- And some faculty members actually tell them to slack off on the teaching. And they may not say it this way, you know, but there are many ways of actually conveying this…And the thing is that the, the image for the students is that teaching, doing this part of academic duty is not a job in the real world. It's actually something that I do to get by until probably I get an R.A., money so I can actually stay 100% in the lab.

4.2. Themes Relating to Particular Course Elements

4.2.1. TA meetings

The course professor held weekly, two-hour long staff meetings. These were designed to help the instructors to be consistent and to understand the course expectations. Although the TAs reported that they gained a lot from these meetings, they also felt that the meetings were in need of adjustment. For instance, most TAs expressed some frustration about the amount of open-ended discussion at the meetings. They felt that their time might have been better spent if the course professor had made executive decisions on some of the more minor course issues.

> I'm just talking about the staff meetings, that, you know I think sometimes that executive decisions should just be made. We don't need to have a group discussion on every single point in the course. Because at some point, you know, you've got to draw the line somewhere. You can't, I don't think, discuss everything, and I think we've drawn the line too far…And I think we should pull it back a little bit.

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> I think maybe [the professor] could run…[the meetings] better, and take more control of the discussion, and lead it in certain directions, and cut it off when it gets going in the wrong direction, or a direction that doesn't need to be addressed. Because I think that's what most of the frustration with me and with other TA's that I've talked to is [about. It's] that you start a discussion and it goes in another direction that doesn't need to be talked about, and it keeps going there for a long time. And then the discussion gets cut off, but you never get back to the point where you originally wanted to talk about. I don't know how to fix that…

In addition to more executive decisions, one TA suggested that problems that affected only individual students or TAs should be discussed with only those individuals, not as a group.

Although TAs were in agreement on this stylistic point regarding the meetings, they differed in their views on the value of particular aspects of the meetings.

4.2.1.1. Two way feedback

The TAs reported that one of agenda items at the meetings was to give the professor feedback on how their students were doing, and on any problems that needed to be addressed. Similarly, the course professor gave the TAs recent, important feedback he might have received over email or through the student board of directors. This was generally viewed as helpful.

4.2.1.2. Reviewing lab

Because this aspect of the TA meetings was not an innovation, the researchers did not focus on this aspect during the interviews. The one TA who commented on this section of the meetings found this very helpful because it helped him/her assist the students in avoiding pitfalls during their experiments.

4.2.1.3. Working on quizzes

During the latter half of the meeting, TAs divided up into two groups, one to write quiz questions for the upcoming week and the other to work on the problem sets or ILRs. Some TAs used a significant portion of the quiz questions developed at the meetings, and thus considered this time well spent.

> R: [At the meetings] we also spend time writing quiz questions, which takes a lot of time, but it saves you a lot of time later in the week.
>
> I: So you actually do it right there?
>
> R: Right there as a group. One thing is that it ensures uniformity throughout the sections on what they're doing on the quizzes but then also it saves you a lot of time later in the week when you know you have to teach in a half an hour and instead of writing the quiz you already have those quiz questions.

Others used fewer of the quiz questions, and thus were more ambivalent about the value of this time spent in the meetings. One of the reasons why some quiz questions were not used was due to changes in the lecture schedule. (See "Section 4.1.3. Communication Problems," above.) One suggestion regarding this portion of the meeting was to reduce the number of quiz questions that the group developed.

4.2.1.4. Working on problem sets or ILRs

TAs were divided on their opinions of the value of working together on the problem sets and ILRs. In addition, not all TAs commented directly on this aspect of the meetings. (This may have been because the TAs could choose which group to work in, and some may not have participated in this group as much as the quiz-writing group.)

Several TAs considered the resulting hint sheet quite valuable in terms of helping the students during workshops. (See, "Section 4.2.3. Workshops," for more on this issue.) Whether or not TAs felt that working together at staff meetings to develop this hint sheet and the answer key was the best way to accomplish this remains an unanswered question.

Two TAs valued working as a group on the assignments because it forced them to grapple with the problem sets or the ILRs before they worked with the students on them. This helped them understand where students were likely to get stuck and what was expected of the students.

> [It's] useful, because while we are working those problems on the integrated lab reports, we encounter the same problems students might encounter. So, we pretty much work [through the problems. And]…after hearing our answer, it's like [the course professor says], "This is what I was expecting from the students." And then at the same time, we say that we don't think students are gonna get it that way, but, you know, we should do it that way, and that way might help. So, at least we see before-hand the problem sets and the integrated lab reports…
>
> When we work on the problems sets, we pretty much work out two [things]…at once. One of them is pretty much coming up with the right answers, but while we are at it, we pretty much come up with the hints that we have to come up with for the students. And at the same time, we see what concept was intended to be covered with each question. So, that helps a lot…
>
> [And then] we pass out an answer sheet which has the hints and has the problems. And that's like crucial. It makes life simpler for us TA's when we go to those workshops.
>
> **********
>
> R: [For] problem sets, I think it's good to have them done in a group. Because even though we are supposed to do this all in a snap, sometimes we get led astray. And it's easier to do it all right then, and then have everybody bring out the answer, and agree and make up the concepts, instead of distributing it and then having to correct it.
>
> I: So what do you think when you are working on the problems together? What do you think the purpose of that is, and what do you think you get out of it?

> R: Well, we work them out together, and it clears it up for us what the process is, you know. Specifically, when we try to take it step-by-step, instead of taking the short cuts we would usually take. And the problems are complex, and we get confused. And doing it in groups helps us to know what's going on…I mean if I do it myself, I'm confident in my abilities to do it right. But I'm always, you know, I want to make sure. [Doing it in groups]…gives me more confidence that I didn't make any silly little error or misunderstand the question. It also helps, if you do it in a group, sometimes you'll catch something or be confused by something that the students will be as well. So that helps, because we can, you know, note [that], put that in the hints, or something like that. So, that will help us in dealing with the students.

It is interesting to note that the TA quoted directly above is one of the TAs who said that s/he would like the course professor to tell the TAs what was expected for each problem, and to give the TAs an answer key. Thus, while this TA supports going through the exercise of solving the problems, but s/he wants the professor, not the TAs, to formulate the expectations.

One TA was more negative about this aspect of the TA meetings, feeling that working through the problems was not an optimal use of graduate students' time. This TA seemed to believe that the objective of this part of the staff meeting was to deal with content knowledge. By contrast, the professor's stated objective was to involve the TAs in a process that would help them anticipate the students' problem-solving process.

> I still think the staff meetings are a little bit too long, and it's a time that is not very good for me personally…I like the concepts. I like the way he approaches it. It's just that if we could limit time spent to certain areas. Say, start off with…the printout of what he expects us [to do], in terms of concepts for students to learn…[Saying], "So here's what we really need to go over." Because I'm assuming most of them, [the TAs], are graduate students and Ph.D.s and…we know, you know, basic concepts.

4.2.2. Discussion

Various approaches

TAs discussed various ways that they structured this time. One TA indicated that in general, his/her discussion sections involved true "discussions" with the students about chemistry.

> For the discussion section, I don't use it as much with the group work. I do more, I don't want to call it lecturing, because it's not really lecturing, but it's meeting with the group, with the whole group, speaking chemistry, and asking them questions, and having them speak chemistry back. And sort of fine tune, trying to

> fine tune how they're using these words, and trying to correct them, and having everybody hear, hear this. I think that, that's important, and that needs to be done, so that they can kind of fine tune how they use these words, and kind of refine how they think of these concepts.

As previously mentioned, at least one TA emphasized groupwork in discussion, attempting to use it during most periods. Others used it sporadically, when they felt there was time.

Feeling forced into a lecturing mode

About half of the TAs mentioned that they often felt forced to fall back into the role of lecturer during the discussion sections for a variety of reasons. As discussed above, one TA encountered resistance from students against groupwork. As in the following quote, another reason for "defaulting" to the lecture mode was that it was difficult to get students to engage in a discussion because they often came unprepared.

> I'm a little turned off with my discussion time right now, because I just haven't been,…well, I've been doing a lot of lecturing, more than I really think I would want to…And so the students end up coming to expect that…[So] they won't come prepared, right. Because they think, you know, "Discussion's going to be another lecture. But I'm going to take a quiz. And hopefully they'll tell me something that I could use." And, you know, the only assignments they turn in is they have a problem set, which is due once every, I don't know, three weeks maybe…So, they don't do it the week before. [So], they don't have anything to do. So, they don't always come prepared in that situation…So, then I'm like, "OK. Well, you know, [I could] try and ask them a question they don't understand," because they haven't studied, because they haven't had anything to practice with.

Another explanation given was that students feared revealing their ignorance, and therefore remained silent during discussion.

> In this culture… students actually believe that admittance of ignorance is the same as saying that somebody's dumb and stupid…[So, as a TA], you have to pound on that issue constantly. And even force students, and say, "Hey! You have to talk to me." One of the things that I say is, you know, "I can know many things, but I'm not actually part of the psychic hotline. So, I don't read minds. You have to let me know if this is OK with you, or not." And then once that I'm able to say, to convey that idea, "Hey, nobody's going to embarrass you in public."

Another TA expressed that s/he was forced to lecture because there was simply too much to cover in a short amount of time, and lecturing was the more efficient way to accomplish all that was necessary.

> I don't like to lecture in discussion section, [because] you get that in lecture. So I try not to do that, but it's happened sometimes, just because there's so much information, and that's the quickest way to get through information. I don't know if it's the best way…[Sometimes] there was just too much information, and it went by really fast in lecture. And it's stuff that they haven't seen before and especially like the proteins stuff they haven't seen before and they don't have a text book reference for it. So. It was just too much. I don't know if they how they feel about it. My feeling is that if you spend the discussion time lecturing they don't get as much time to do problems and learn the problem solving skills which is what they need to take an exam.

Having to improvise

As previously discussed, TAs often felt that they were not fully informed about what would be addressed during lecture. Therefore, it was necessary for them to improvise in terms of how to structure their time in discussion. This included sometimes re-writing quizzes to make sure that they were in synch with the lecture topics.

4.2.3. Workshops

Viewed as an important classtime structure

TAs indicated that the workshops were well structured and provided a good opportunity for students to get more guidance from the TAs on the assignments while still working primarily with other students. At least one TA felt that the fact that there were workshops meant there was more time in discussion to talk about the chemistry concepts because they did not have to focus so much on the assignments.

TA role

The TAs discussed that they largely helped keep students on track during the workshops by helping them focus on the important aspects of the questions. The following TA quote illustrates this point.

> R: …It's an effort to keep them from wasting time, and reinforcing bad chemistry. What can happen with these problem sets is that since it isn't just, "Punch these numbers into the equation," and they're very open-ended, and they're essay, and they can bring in whatever concept they want, [and] some of them are appropriate, and some of them aren't. And so if they get on talking about these other things that aren't necessarily appropriate for that problem, but they think that it's related somehow, in some way, but it really isn't, then they can spend a lot of time sort of talking about this in their group, and reinforcing those things that's not necessarily correct. And, you know, that happens. You know, not all the time, but every once in a while. And so this is an effort to get rid of that. That, if they're a little unsure, to ask somebody and just make sure that they're thinking about the right things.

Helpfulness of hint sheets

Several of the TAs indicated that they relied upon the hint sheets developed at the TA meetings to help them understand what issues the students should focus on, and what they could and could not tell students. They expressed some concern about giving certain students unfair advantages by telling them more than other students. The hint sheets helped alleviate this concern.

> R: [During the staff meetings] half of the TA's will work on the problem set and will generate an answer key…The group that generates the answer key will give out a copy to all the TA's. And I just got one this morning for this problem set that was very well done. I glanced at it, and it had all the answers written out, plus what they also do is they write out hints. Good hints that you can give to students in the workshop room. So, [it's] information that you could give that [says] basically, "This is what you should be thinking about, to get you on the right track." Which has helped a lot. Because then it kind of let's you know what you can tell them and what you can't. Because the workshop rooms aren't for TA's to be giving them an answer, just to give them directions. So they tell us when, you know--
>
> I: Stumbling blocks?
>
> R: Yeah, stumbling blocks, questions that students will probably have and common directions that you can lead them on. So that's been a big help.

****

I: So how do you interact with the students at the workshops?

R: Usually I try to keep a really low profile. Because it's hard to, this seems to be particularly had to figure out how much guidance you would want to give to them, because it's different than a problem in discussion…[In discussion], I figure you can give more, because it's not like you are going to be--Like, giving one group more guidance than another in discussion is not unfair, because…there's no grade involved. And you're going to be going over it in discussion anyhow. And so like, I feel a little bit more free when I tell them stuff in discussions than I can be in the workshops. So we've made up a sheet of specific hints we can tell people. Like, specific concepts, "Go back in your book, and find that, and then figure it out." which helps…

4.2.4. Lab

Various ways of preparing students

TAs discussed various ways that they prepared students for lab including spending time in discussion, writing notes to students through email, and beginning the lab period with an overview of the experiment. One TA mentioned that there was not as much time to prepare for labs during discussion because of the need to address questions about lecture material.

TA roles during lab

Some TAs indicated that during lab they walked around the room and made themselves available for questions. Other TAs indicated that they made a point to ask the students questions about what they were doing and why. The following quotes illustrate this latter approach.

Pretty much most of the stuff about procedure we have done in discussion section, and so they know what's going on before they show up for lab. And after that, I'm pretty much walking through the lab and seeing how they are doing, and I'm asking them how they are doing. And throughout the lab, if someone is done I say, "For this part of the procedure, show me the data." And after that I pretty much ask them questions regarding the data to see if it makes sense to them. And at least that seems to help out when they are writing down their lab reports.

****

[Sometimes in lab] students ask me, “Oh yeah, I got that. Is this right?” [And I say], “OK, nonono. Tell me what you got. OK, what did you do here? What did you do here?” And then I actually start asking them questions. And I actually am a firm believer in the Socratic method. And then I try to actually ask them questions that will fine-tune or focus what they are doing, and [I ask], "Why are you doing

> this? What is it that you're accomplishing by doing this?" Like for example, "Let's explore. What do you know about proteins? About their nature, are they polar or non-polar? What do you know about phosphate? Is that an iron, is that a molecule? What is it?" So, by asking questions on basic pieces of information or knowledge, I try to help them to actually fine-tune what they're doing. So he eventually says, "OK." And sometimes I find students of mine who actually…are able to…[say], "OK, I'm getting this probably because of this, or this, or this." And then I'll say, "They got it." Because to me, if somebody understands the concept, one of the things that the person will be able to do is to explain it. If you're able to explain…what's happening here, then it means that you've got the concept.

Students who described their TAs as using a strict guide-on-the-side approach during lab expressed frustration with this approach, as it made them uncertain if they were doing the right thing. A related issue mentioned by a few TAs was that sometimes it was difficult to get students to think about the conceptual issues underlying the labs prior the ILRs because of the point structure for lab and the lower level of coordination between lab and lecture during the last half of the semester.

5. Conclusion

Overall, the TOA Chem 104 course appears to be a work-in-progress with tremendous potential to enhance the student learning process and outcomes. However, there are still significant implementation problems that make the course less effective than it could be for students and more challenging and time-consuming for the instructors.

As the course will taught for the third time in the Spring of 1998, currently the course professor and one or more of the TAs are working on materials which would alleviate some of these problems, such as a more detailed course syllabus and a standardized course packet of reading materials. We hope that this report will be useful in guiding those planning efforts.

Appendix A: Interview Protocols

LEAD Center Chem 104 Evaluation
Interview Guide

Students Enrolled in TOA Chem 104, Spring 1997

Introductions and presentation of the Informed Consent form.

Briefly review points from the Informed Consent, focusing on how the evaluation and assessment process relies on learning about what and how well students are learning in this course. The evaluators are allies who can help students communicate things to the instructors that might be awkward for students to say directly. Check that the student is comfortable with the tape recorder. If not, just take notes.

Background

1. Please tell me a little about where you are from and what type of high school you attended.

2. Tell me about your preparation for college math and science courses. [Prompt: If someone says that they are either ahead or behind other people, ask, "How do you know?"]

3. Tell me a little about ideas you have for a major, or possible plans for your future professional life. Have your plans for a major changed since last semester?

4. Tell me a little about your experience in Chem 103. How did it go? Who was your professor?

Chem 103

5. Why did you register for [this section of]'s 104? [Probe for whether or not they knew about the teaching innovations.]

6. What were your first impressions of Chem 104? [Probe for whether or not they were surprised or distressed by the groupwork or other differences.]

7. If you had to specify one thing that is helping you learn chemistry the most this semester, what would it be? Why?

Lecture-related questions

8. Can you describe the lecture section of your class? What does the professor do, what do you do?

9. a) Do you think that your lecture section is an effective way for you to learn chemistry? Please explain.

    b) Is there any aspect of the lecture section that you particularly like or think is particularly effective for you? Can you explain and give an example?

    c) Is there any aspect of the lecture section that you particularly dislike or think is not effective for you? Can you explain and give an example?

10. Tell me what you think about the participation element of the lectures: when [Professor X] asks you to either raise your hand and answer a question or discuss the question with your neighbor.

    a) How, if at all, do they help you learn chemistry? b) Are there any other benefits or detriments to engaging in this activity?

Laboratory

11. Can you describe the laboratory section of your class?

12. What, if anything, are you learning? [Probe for lab technique, concepts, etc.]

13. Do you think that the laboratory section is an effective way for you to learn chemistry? Please explain.

14. Is there any aspect of the lab that you particularly like or think is particularly effective for you? Can you explain and give an example?

15. Is there any aspect of the lab section that you particularly dislike or think is not effective for you? Can you explain and give an example?

16. Can you describe the labs? [Probe from cookbook vs. inquiry-based.]

17. Tell me about the integrated lab reports. How, if at all, do they help you learn chemistry?

18. How, if at all, does the physical environment in the lab affect your experience in lab either negatively or positively?

Discussion Section

19. Can you describe your discussion section? What typically happens during discussion?

20. Do you think that the discussion section is an effective way for you to learn chemistry? Please explain.

21. Is there any aspect of the discussion section that you particularly like or think is particularly effective for you? Can you explain and give an example?

22. Is there any aspect of the discussion section that you particularly dislike or think is not effective for you? Can you explain and give an example?

Topic-oriented Approach

23. The professor in this course is using what he calls a "topic-oriented approach" to teaching.

a) What do you think of this approach?
b) Are there positive effects for you?
c) Negative? [Prompt for effects on learning and on attitude.]

24. Do you notice other differences in this professor's approach that you would like to comment on?

25. What is your reaction to the nature of the quizzes, problem sets and exams? Integrated lab reports? [Probe for their reaction to the shift from doing calculation-based problems to writing out their answers in essay form and addressing concepts.]

Roles

26. a) How important is the TA to your learning of chemistry in this course? b) The professor? c) Other students?

Workshops

27. Have you attended any of the workshops?

a) If not, why not? [Prompt for what might make them to go.]
b) If so…Tell me what it was like.

What did you work on?
Did you go with a group of other students?
How did you interact with the other students in your group? With the TA?
Did you go to the workshop with your own TA or with another TA? [If another TA]: What was your reaction to working with a new TA?

c) What, if anything, did you get out of it?

d) Why did/do you go?

General Questions

28. Has taking this course changed the way you think about chemistry?

29. Is there anything else that you can tell us to help us understand your experience in this class?

30. Do you have any questions for me?

LEAD Center Chem 104 Evaluation
Interview Guide

Spring 1997

Chem 104 Teaching Assistants

Introductions and presentation of the Informed Consent form.

Briefly review points from the Informed Consent. Check that the instructor is comfortable with the tape recorder. If not, just take notes.

Background (for TAs who did not complete a pre-survey)

1.Take a few minutes and give me a brief history of yourself - a history that helps me to understand how you came to be a TA in this course.

2. What, if any, preparation did you receive to be a TA in Chem 104? {Probe for formal and informal experiences}

3. What were your initial expectations about what it would be like to teach in this course?

Goals (for TAs who did not complete a pre-survey)

4. What are your goals for student learning in Chem 104?

5. What are the professor's goals for student learning in Chem 104? How, if at all, do your goals differ from the professor's goals?

6. When you started this course, how confident were you that it would be successful? {Probe for thoughts about groupwork.}

General Questions about 104 (for all TAs)

7. Do you have separate goals for the different course components, such as discussion, lab, and workshops? If so, please describe?

8. Could you describe what you do as a TA for Chem 104? How, if at all, does this differ from what you've done as a TA for other lower level chemistry courses?

9. How is the course going, at this point?

10. Do you feel that you are meeting your expectations/goals for yourself? Why, or why not? Are there things that have hindered your ability to do this?

11. What have been the hardest things for these students to learn? Were there particular things you did that seemed to help? Were these new strategies for you?

Lab

12. How would you characterize the labs for this course? How, if at all, are they different from other labs you know about?

13. To what degree are the lab experiments coordinated and integrated with the lecture part of this course? How, if at all, does this affect students' learning?

14. How is lab going at this point?

15. What do you do in the lab? [Prompt: what role do you play?]

16. How much do you feel students are learning in the labs? [Prompt: What kinds of things are they getting out of lab (conceptualization of principles, lab technique, etc.)?]

17. In your opinion, how do the integrated lab reports affect student learning? {Probe for effects of other "unique" elements of lab.}

18. How do students relate to each other and to you in the lab? Is there organized groupwork? How effectively do the students seem to work together in lab?

19. Do the labs help the students to understand the course concepts?

Discussion sections

20. Please describe your discussion sections. What you do in discussion section? What do students do?

21. How is discussion section going at this point?

22. What, if anything, do you feel students get out of discussion section? {Probe: How much do you feel students are *learning* in discussion?}

Lecture

23. Do you attend lecture? If so, can you describe what the lecturer is like and the regular features of the lectures?

24. In your opinion, to what degree does attending the Chem 104 lecture help your students learn chemistry? Please explain.

25. What is the role of the lecture in this course? What do students gain? Miss?

26. How does the lecture shape your role as a TA for this course?

Workshops

27. Describe what happens at the weekly workshops? What are they like? What role do you play? How do the students interact?

28. From your experience, what, if anything, do you feel students get out of attending?

29. How many people usually attend?

Is it usually the same group of students?
Is there a particular type of student who tends to attend?
Do you have any ideas on why the ones who don't attend, don't attend?

TA meetings

30. Can you describe the TA meetings. What are they like? What is the purpose of the meetings?

31. What, if anything, do you get out of them?

32. Can you compare these meetings with TA meetings for other courses you have taught?

33. Are student concerns/difficulty with the course discussed at these meetings? Are strategies for addressing these problems devised?

34. Have you ever worked in the group that works on the problem sets for the workshops? If so, what effect, if any, has this had on your ability to facilitate the workshops (probe for examples?

35. Have you ever worked in the group which develops the quiz questions? Tell me about this process, and what, if anything, you and the other TAs gain from it.

36. Do you have any suggestions for changes to the TA meetings?

37. Having come close to the end of the semester, what is your opinion on the adequacy of TA training for this course?

Were there aspects for which you felt the TAs could have used more preparation?
Aspects which were particularly difficult?
Anything else that could have been done to make you as successful as possible?

Closure

38. Are there particular problems that you or the students have experienced in this course that we have not already discussed?

39. Do you have any other thoughts about the efficacy of particular teaching strategies that you or the course professor have been employing?

40. We will be interviewing students soon. Do you have issues that you want discussed or specific questions you would like the students to discuss?

41. Is there anything else you can tell us in order for us to understand Chem 104 better?

42. Do you have any questions or comments that you would like to share with me?

Initial Interview with TOA Course Professor, Spring 1997

Introductions and presentation of the Informed Consent form.

Briefly review points from the Informed Consent. Check that the instructor is comfortable with the tape recorder. If not, just take notes.

1. What are your goals for student learning in Chem 104?

2. Please tell me about your approach to Chem 104 this semester?

3. Please describe the activities and your assessment structure and rationale.

4. Why did you choose to implement the curricular innovations which you are using? What effect, if any, do you believe they will have on student learning?

5. Tell me how the ConcepTests are proceeding? How are the students reacting?

6. In your course the TAs are involved in implementing some of your educational reforms, such as the workshops and acting more as a "guide-on-the-side." How is this going?

7. What are your goals for TA training in this course? Your strategies? Why did you decide on those particular strategies?

8. As you gain experience with these particular pedagogical methods, have you found that you have had to make changes in the way you implement them? If so, please explain.

9. Are there any questions which you would like use to ask the students in Chem 104 during our interviews with them?

10. Are there anyquestions which you would like us to ask the TAs during our interviews with them?

11. Is there anything else about Chem 104 that you would like to share with me?

Protocol for Second Interview with TOA Chem 104 Course Professor Spring 1997

Overall issues

1. Overall, how did the course go this semester?

2. To what degree do you think your goals were achieved?

3. You indicated that in addition to wanting to improve student learning, you were motivated to adopt this teaching style because you felt it would be more interesting for you. From your perspective, how does teaching with this approach differ?

4. Did this course take any more or less time than a more traditional 104 for you the students, or the TAs? If so, do you think it is worth it?

5. It seems to me that you view this course as still evolving. You made a lot of changes this semester. What went well this semester and what didn't?

6. What changes do you plan to make for the next time you teach 104? Why?

Issues relating to specific course elements

7. Do you have any new observations or thoughts about how voluntary groupwork works that you would like to share with me?

8. How did lecture go? {Probe for new thoughts about the thematic approach and particular challenges.}

9. How did the ConcepTests these go? Did you make any changes in the way you were implementing them? If so, why and how did this go?

10. Tell me how the assignments went. [Ask about integrated lab reports, exams, and problem sets.]

11. How did the workshops go? How much do you think they changed the course? Will you do them again?

12. Tell me about the student feedback mechanisms and how those worked, especially the student board and roaming the labs.

13. Tell me how the TA meetings went. What effect do you think they had on the TAs?

14. Did you modify the TA meetings at any point. If so, why?

Closure

15. Would you like to discuss any other lessons you have learned from teaching this course?

Appendix B: Student and TA Surveys

Beginning-of-Semester
College Chemistry Course Survey

developed by
The Learning through Evaluation, Adaptation and Dissemination (LEAD) Center
University of Wisconsin Madison

for the education reform project,
"New Traditions: Revitalizing the Curriculum"

This study is funded by the "New Traditions: Revitalizing the Curriculum" grant, DUE-9455928, administered by the National Science Foundation and awarded to the University of Wisconsin's Chemistry Department.

Chemistry Course Survey Consent Form for Students

The Learning through Evaluation, Adaptation and Dissemination (LEAD) Center is conducting a survey of some of the Chemistry Department's undergraduate courses. The survey is designed to assist faculty in understanding the effects of course innovations on students' learning experiences and may lead to improvements in the teaching of chemistry nationwide.

We are asking students who are enrolled in the participating lectures to complete a brief survey about their learning experiences in the course. The survey should take about ten minutes to complete. In order to correlate responses with demographic data and measures of achievement we are asking you to write your Student I.D. number on the survey.

All student responses will be held strictly confidential. The LEAD Center will generalize about student responses so as to obscure the identity of any particular students before reporting any survey findings. The LEAD Center may publish papers based on the results of this survey, but these materials will contain no information that would identify particular students.

Participation is completely voluntary. (Students choosing not to participate may simply return a blank survey). Refusal to participate will have no effect on your grade. There are no formal benefits or risks associated with participation.

Any questions you have you may ask now, or you may call Dr. Susan Millar, Director, LEAD Center, at 265-5943.

I have read the above and give my consent to participate in the study.

Signature _____ Date _____

STUDENT I.D. Number _____

(Please write your I.D. both here and fill in it in on the upper left corner of the "bubble" sheet)

The LEAD Center wishes to thank you for participating in this national study of how students learn in college chemistry courses. The questions in the survey are intended to help LEAD Center researchers understand your experiences in the chemistry course in which this survey is being administered. Your thoughtful responses to the questions in this survey will enable us to help faculty across the nation improve chemistry education.

Copies of this consent form can be obtained at the LEAD Center room 427, 1402 University Ave.

Please assess your ***CONFIDENCE*** levels in the areas below ***BEFORE*** attending this course. **(Fill in the appropriate number on the bubble sheet).**

	CONFIDENCE IN YOUR ABILITY TO...	**confidence level**					
		low					**high**
1.	understand key concepts of chemistry…..	**0**	**1**	**2**	**3**	**4**	**5**
2.	solve chemistry problems.....….	**0**	**1**	**2**	**3**	**4**	**5**
3.	understand the chemistry of lab experiments.....……	**0**	**1**	**2**	**3**	**4**	**5**
4.	perform lab experiments.....….	**0**	**1**	**2**	**3**	**4**	**5**
5.	visualize key concepts of chemistry.....….	**0**	**1**	**2**	**3**	**4**	**5**
6.	apply your knowledge of chemistry to the real world.....……	**0**	**1**	**2**	**3**	**4**	**5**
7.	understand other areas of science.....….	**0**	**1**	**2**	**3**	**4**	**5**
8.	succeed in Chem 104…….	**0**	**1**	**2**	**3**	**4**	**5**
9.	succeed in a chemistry-related field…	**0**	**1**	**2**	**3**	**4**	**5**

10.	What grade do you expect in this course?	**For…**	C	BC	B	AB	A	other
		Fill in…	**0**	**1**	**2**	**3**	**4**	**5**

Please indicate how important you believe the following factors will be to your ***learning*** chemistry in this course***:*** **(Fill in the appropriate number on the bubble sheet).**

		not very important					**very important**	**don't know**
11.	the professor	**0**	**1**	**2**	**3**	**4**	**5**	**6**
12.	the TA	**0**	**1**	**2**	**3**	**4**	**5**	**6**
13.	attending lecture	**0**	**1**	**2**	**3**	**4**	**5**	**6**
14.	attending discussion	**0**	**1**	**2**	**3**	**4**	**5**	**6**
15.	live chemical demonstrations in lecture	**0**	**1**	**2**	**3**	**4**	**5**	**6**
16.	video-taped chemistry demonstrations	**0**	**1**	**2**	**3**	**4**	**5**	**6**
17.	video animation of chemical concepts	**0**	**1**	**2**	**3**	**4**	**5**	**6**
18.	the professor stopping lecture to allow students to discuss concepts	**0**	**1**	**2**	**3**	**4**	**5**	**6**
19.	having a detailed course syllabus	**0**	**1**	**2**	**3**	**4**	**5**	**6**
20.	working on your own	**0**	**1**	**2**	**3**	**4**	**5**	**6**
21.	doing homework problems	**0**	**1**	**2**	**3**	**4**	**5**	**6**
22.	doing additional non-required exercises	**0**	**1**	**2**	**3**	**4**	**5**	**6**
23.	reading sample problems in the text	**0**	**1**	**2**	**3**	**4**	**5**	**6**
24.	reading explanations in the text	**0**	**1**	**2**	**3**	**4**	**5**	**6**
25.	talking with your professor	**0**	**1**	**2**	**3**	**4**	**5**	**6**
26.	talking with your TA	**0**	**1**	**2**	**3**	**4**	**5**	**6**
27.	interacting with your professor by e-mail	**0**	**1**	**2**	**3**	**4**	**5**	**6**
28.	working in groups in discussion	**0**	**1**	**2**	**3**	**4**	**5**	**6**
29.	working in groups in lab	**0**	**1**	**2**	**3**	**4**	**5**	**6**
30.	working with friends (out of class)	**0**	**1**	**2**	**3**	**4**	**5**	**6**
31.	performing lab experiments	**0**	**1**	**2**	**3**	**4**	**5**	**6**

(Please continue to question 32 on page 3.)

Please indicate how often you attended Chem 103 lectures and discussion sections by filling in the appropriate number on the bubble sheet.

		If you…	rarely attended (0-60%)	often attended (60-80%)	usually attended (80-95%)	almost always attended (95-100%)
32.	Chem 103 lecture:	**Fill in…**	**0**	**1**	**2**	**3**
33.	Chem 103 discussion:	**Fill in…**	**0**	**1**	**2**	**3**

Thank you for your participation!

Chem 104
End-of-Semester Survey

developed by

The Learning through Evaluation, Adaptation and Dissemination (LEAD) Center
University of Wisconsin Madison

for the education reform project,
"New Traditions: Revitalizing the Curriculum"

This study is funded by the "New Traditions: Revitalizing the Curriculum" grant, DUE-9455928, administered by the National Science Foundation and awarded to the University of Wisconsin's Chemistry Department.

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Signature _____ Date _____

STUDENT I.D. Number _____

(Please write your I.D. both here and fill in it in on the upper left corner of the "bubble" sheet)

The LEAD Center wishes to thank you for participating in this national study of how students learn in college chemistry courses. The questions in the survey are intended to help LEAD Center researchers understand your experiences in the chemistry course in which this survey is being administered. Your thoughtful responses to the questions in this survey will enable us to help faculty across the nation improve chemistry education.

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Please fill in your responses using a no. 2 pencil on the separate bubble sheet.

BACKGROUND: **1) semesters of high school chemistry: 0 1 2 3** over 3 **(fill in bubble 4)**
2) semesters of high school math: 0 1 2 3 4 5 6 7 8

For each group of factors below please fill in a number on the bubble sheet to indicate the ***relative impact*** of each factor on your ***LEARNING*** overall in this course. ***NOT ALL ACTIVITIES APPLY TO ALL SECTIONS OF THIS COURSE.***

relative impact on your ***LEARNING*** overall

	PEOPLE	**not applicable**	**negative**			**neutral**			**positive**
3)	professor	0	1	2	3	4	5	6	7
4)	TA/lab instructor	0	1	2	3	4	5	6	7
5)	friends/informal groups	0	1	2	3	4	5	6	7
6)	course organized groups	0	1	2	3	4	5	6	7
7)	Chem Learning Center	0	1	2	3	4	5	6	7

relative impact on your ***LEARNING*** overall

	ACTIVITIES/ MATERIALS								
8)	lecture—overall	0	1	2	3	4	5	6	7
9)	-- questions posed to class	0	1	2	3	4	5	6	7
10)	-- demonstrations	0	1	2	3	4	5	6	7
11)	-- exams	0	1	2	3	4	5	6	7
12)	labs—overall	0	1	2	3	4	5	6	7
13)	-- UW ChemPages	0	1	2	3	4	5	6	7
14)	-- regular lab reports	0	1	2	3	4	5	6	7
15)	-- integrated lab reports	0	1	2	3	4	5	6	7
16)	-- lab manual	0	1	2	3	4	5	6	7
17)	discussion—overall	0	1	2	3	4	5	6	7
18)	-- Challenge Problems	0	1	2	3	4	5	6	7
19)	-- problem sets	0	1	2	3	4	5	6	7
20)	other--Chem You Can Do	0	1	2	3	4	5	6	7
21)	-- quizzes	0	1	2	3	4	5	6	7
22)	-- the textbook	0	1	2	3	4	5	6	7
23)	-- weekly computer exercises	0	1	2	3	4	5	6	7
24)	-- special computer assignments	0	1	2	3	4	5	6	7
25)	-- workshops	0	1	2	3	4	5	6	7

For each group of factors below please fill in a number on the bubble sheet to indicate the ***relative impact*** of each factor on your ***CONFIDENCE*** in your ability to understand and do chemistry.

relative impact on your ***CONFIDENCE***

	PEOPLE	**not applicable**	**negative**			**neutral**			**positive**
26)	professor	0	1	2	3	4	5	6	7
27)	TA/lab instructor	0	1	2	3	4	5	6	7
28)	friends/informal groups	0	1	2	3	4	5	6	7
29)	course organized groups	0	1	2	3	4	5	6	7
30)	Chem Learning Center	0	1	2	3	4	5	6	7

relative impact on your ***CONFIDENCE***

	ACTIVITIES/ MATERIALS								
31)	lecture—overall	0	1	2	3	4	5	6	7
32)	-- questions posed to class	0	1	2	3	4	5	6	7
33)	-- demonstrations	0	1	2	3	4	5	6	7
34)	-- exams	0	1	2	3	4	5	6	7
35)	-- quizzes	0	1	2	3	4	5	6	7
36)	labs—overall	0	1	2	3	4	5	6	7
37)	-- UW-ChemPages	0	1	2	3	4	5	6	7
38)	-- regular lab reports	0	1	2	3	4	5	6	7
39)	-- integrated lab reports	0	1	2	3	4	5	6	7
40)	-- lab manual	0	1	2	3	4	5	6	7
41)	discussion—overall	0	1	2	3	4	5	6	7
42)	-- Challenge Problems	0	1	2	3	4	5	6	7
43)	-- problem sets	0	1	2	3	4	5	6	7

		not applicable	negative			neutral			positive
44)	other-- Chem You Can Do	0	1	2	3	4	5	6	7
45)	-- quizzes	0	1	2	3	4	5	6	7
46)	-- the textbook	0	1	2	3	4	5	6	7
47)	-- weekly computer exercises	0	1	2	3	4	5	6	7
48)	-- special computer assignments	0	1	2	3	4	5	6	7
49)	-- workshops	0	1	2	3	4	5	6	7

Please compare your ***INTEREST*** levels in the areas below ***BEFORE*** and ***AFTER*** taking this course.
(Fill in a number on the bubble sheet for each row.)

INTEREST IN...			**interest level**					
			low					**high**
science in general.....	**50)**	**before**	0	1	2	3	4	5
	51)	**after**	0	1	2	3	4	5
chemistry in general.....……..	**52)**	**before**	0	1	2	3	4	5
	53)	**after**	0	1	2	3	4	5
taking more chemistry.....	**54)**	**before**	0	1	2	3	4	5
	55)	**after**	0	1	2	3	4	5
pursuing a chemistry-related major....	**56)**	**before**	0	1	2	3	4	5
	57)	**after**	0	1	2	3	4	5
pursuing a science-related field	**58)**	**before**	0	1	2	3	4	5
	59)	**after**	0	1	2	3	4	5
working with others to learn science...	**60)**	**before**	0	1	2	3	4	5
	61)	**after**	0	1	2	3	4	5

Please assess your ***CONFIDENCE*** levels in the areas below ***AFTER*** attending this course. **(Fill in the appropriate number on the bubble sheet).**

	CONFIDENCE IN YOUR ABILITY TO...	**confidence level**					
		low					**high**
62)	understand key concepts of chemistry.....	**0**	**1**	**2**	**3**	**4**	**5**
63)	solve chemistry problems.....	**0**	**1**	**2**	**3**	**4**	**5**
64)	understand the chemistry of lab experiments…..	**0**	**1**	**2**	**3**	**4**	**5**
65)	perform lab experiments.....	**0**	**1**	**2**	**3**	**4**	**5**
66)	visualize key concepts of chemistry.....	**0**	**1**	**2**	**3**	**4**	**5**
67)	apply your knowledge of chemistry to the real world.....	**0**	**1**	**2**	**3**	**4**	**5**
68)	understand other areas of science.....	**0**	**1**	**2**	**3**	**4**	**5**
69)	succeed in this chemistry course.....……	**0**	**1**	**2**	**3**	**4**	**5**
70)	succeed in a chemistry-related discipline	**0**	**1**	**2**	**3**	**4**	**5**

71)	What grade do you expect in this course?	**For…**	C	BC	B	AB	A	other
		Fill in…	**0**	**1**	**2**	**3**	**4**	**5**

Please rate the ***relative importance*** of each of the factors below in terms how you might approach ***solving a difficult chemistry problem:*** **(Fill in the appropriate number on the bubble sheet.)**

		not very important					**very important**	**not applicable**
72)	working on your own	**0**	**1**	**2**	**3**	**4**	**5**	**6**
73)	doing similar homework problems	**0**	**1**	**2**	**3**	**4**	**5**	**6**
74)	reading sample problems in the text	**0**	**1**	**2**	**3**	**4**	**5**	**6**
75)	reading explanations in the text	**0**	**1**	**2**	**3**	**4**	**5**	**6**
76)	asking your professor	**0**	**1**	**2**	**3**	**4**	**5**	**6**
77)	asking your TA/lab instructor	**0**	**1**	**2**	**3**	**4**	**5**	**6**
78)	working in course-organized groups	**0**	**1**	**2**	**3**	**4**	**5**	**6**
79)	working with friends/informal groups	**0**	**1**	**2**	**3**	**4**	**5**	**6**

Please rate the ***relative importance*** of each of the factors below in terms of helping you to ***grasp difficult concepts in chemistry:*** **(Fill in the appropriate number on the bubble sheet.)**

		not very important					very important	not applicable
80)	lab experiments	**0**	**1**	**2**	**3**	**4**	**5**	**6**
81)	regular lab reports	**0**	**1**	**2**	**3**	**4**	**5**	**6**
82)	integrated lab reports	**0**	**1**	**2**	**3**	**4**	**5**	**6**
83)	working on your own	**0**	**1**	**2**	**3**	**4**	**5**	**6**
84)	doing homework problems (problem sets)	**0**	**1**	**2**	**3**	**4**	**5**	**6**
85)	reading sample problems in the text	**0**	**1**	**2**	**3**	**4**	**5**	**6**
86)	reading explanations in the text	**0**	**1**	**2**	**3**	**4**	**5**	**6**
87)	asking your professor	**0**	**1**	**2**	**3**	**4**	**5**	**6**
88)	asking your TA/lab instructor	**0**	**1**	**2**	**3**	**4**	**5**	**6**
89)	working in course-organized groups	**0**	**1**	**2**	**3**	**4**	**5**	**6**
90)	working with friends/informal groups	**0**	**1**	**2**	**3**	**4**	**5**	**6**

For each statement please fill in **one** number on the bubble sheet which best represents your view.

	LAB EXPERIMENTS	**strongly disagree**					**strongl agree**
91)	The labs helped me understand important concepts in this course.	0	1	2	3	4	5
92)	The labs were an effective way to learn laboratory procedures.	0	1	2	3	4	5
93)	The labs related well to the lecture material.	0	1	2	3	4	5
94)	My TA was effective in helping me learn from the labs.	0	1	2	3	4	5
95)	My lab partners were effective in helping me learn from the labs.	0	1	2	3	4	5
96)	I understood the chemistry concepts behind the labs before I did them.	0	1	2	3	4	5
97)	Eventually, I understood the chemistry behind the labs.	0	1	2	3	4	5
98)	The labs related well to the lecture material.	0	1	2	3	4	5
99)	Often, enough time was not allowed for labs.	0	1	2	3	4	5
100)	Usually, everyone in my lab group contributed about equally.	0	1	2	3	4	5
101)	I would have learned more if I had done the labs on my own.	0	1	2	3	4	5
102)	I was an effective contributor to my lab group.	0	1	2	3	4	5
103)	While doing the lab, I sometimes thought about the concepts the lab illustrated.	0	1	2	3	4	5

NOTE: The following blocks of questions apply only to sections taught by Professors X and Y. ***Please skip the blocks that do not apply to you. Be sure to leave your bubble sheet blank as appropriate.***

	***PROFESSOR X'S* CLASS ONLY**	**strongly disagree**					**strong agree**
104)	The Challenge Problems were an effective way to learn key chemistry concepts.	0	1	2	3	4	5
105)	Often, enough time was not allowed for Challenge Problems.	0	1	2	3	4	5
106)	My TA was effective in helping me learn from the Challenge Problems.	0	1	2	3	4	5
107)	Often, the Challenge Problems were so hard they were a waste of time.	0	1	2	3	4	5
108)	Doing the Challenge Problems increased my confidence that I could succeed in this course.	0	1	2	3	4	5
109)	My group was effective in helping me learn from the Challenge Problems.	0	1	2	3	4	5
110)	Usually, everyone in my Challenge Problem group contributed about equally.	0	1	2	3	4	5
111)	I would have learned more if I had done the Challenge Problems on my own.	0	1	2	3	4	5
112)	While doing the Challenge Problems, I sometimes felt that my group was dominated by one or two people.	0	1	2	3	4	5
113)	I was an effective contributor to my Challenge Problem group.	0	1	2	3	4	5

	***PROFESSOR Y'S* CLASS ONLY**	**strongly disagree**					**strong agree**
104)	Using "real world" issues and examples in this class *helped me to learn* the material more easily.	0	1	2	3	4	5
105)	Using "real world" issues and examples in this class *stimulated my interest* in the material.	0	1	2	3	4	5
106)	Doing the integrated lab reports helped me to understand the concepts behind the laboratory exercises.	0	1	2	3	4	5
107)	I would have preferred a more traditional approach in which math and chemical equations were emphasized more heavily.	0	1	2	3	4	5
108)	Writing about chemistry concepts for assignments and exams helped me to learn the material in this course.	0	1	2	3	4	5
109)	As a student in this course, I felt confident that if I studied for the exams, I would do well.	0	1	2	3	4	5
110)	Working with other students helped me a great deal in this class.	0	1	2	3	4	5
111)	The questions the professor asked students during lecture helped me stay interested in what he was saying.	0	1	2	3	4	5
112)	In general, the type of assistance my TA gave me helped me to learn the course material.	0	1	2	3	4	5
113)	I felt that my TA generally understood what was expected of the students on assignments.	0	1	2	3	4	5

GENERAL (*all students*): (Fill in the appropriate response)

114)	I am confident that, having taken this Chem 104 course, I would be prepared for subsequent *chemistry* courses.	0	1	2	3	4	5
115)	I am confident that, having taken this Chem 104 course, I am prepared for additional *science* courses.	0	1	2	3	4	5

116)	I am planning to take additional chemistry courses	**for…**	no	yes
		fill in…	**0**	**1**

hours per week

117) Average hours each week spent on this course (*outside of* class, discussion, and laboratory):

for...	0-5 hr.	5-10 hr.	10-15 hr.	15-20 hr.	over 20 hr.
fill in...	**0**	**1**	**2**	**3**	**4**

118) Average hours each week spent on this course *studying or working with other students:*

for...	0-5 hr.	5-10 hr.	10-15 hr.	15-20 hr.	over 20 hr.
fill in...	**0**	**1**	**2**	**3**	**4**

		definitely not recommend					**definitely recommend**
119)	**Would you recommend this course to a friend?**	0	1	2	3	4	5

THANK YOU !

Beginning-of-Semester Teaching Assistant Survey
Topic-Oriented Approach to Chemistry 104/Spring Semester 1996

Name _____

As you may know, the Chemistry Department has received a federal grant to try different approaches to undergraduate teaching. As a part of this project , we want to get some of your ideas about your work as a TA and the Chemistry 104 course. We may share some of this information with the professor to help his general planning. However, the information we pass on will be anonymous. In other words, the professor won't know which TA made which comment.

1. Please tell us a little bit about your background:

    a. How did you come to be a TA in this particular course?

    b. How will teaching in this course fit into your own long-term professional goals?

    c. Have you had any previous teaching experience? Please explain what kind.

    d. Have you had any special training in teaching methods? Please explain what kind.

    e. Do you expect this course (Chemistry 104) to be a lot different from other chemistry courses you have taught or taken? Please explain.

2. Now, please tell us something about how you think about your role as a TA:

    a. What do you think the students expect of you?

    b. What do you think the professor expects of you?

    c. What do you expect of yourself?

3. We're also interested in your thoughts about the goals of this course:

    a. Do you think you have a clear understanding of what the professor expects the students in this course to come away with? Describe these expectations briefly.

    b. Do you think these expectations will be met? Why or why not?

    c. Are there some elements of the course that you think will be more or less effective than others? Explain.

4. What does the term “topic oriented approach” mean to you?

    a. Is this something you’ve had experience with before? Please explain.

    b. What do think of this approach?

5. How about a “group work” approach?

    a. Is this something you’ve had experience with before? Please explain.

    b. What do you think of this approach?

6. On a scale of one to five, how interested are you at this point in teaching? (Circle.)

Not at all				Very
1	2	3	4	5

7. Tell us what you think you most need at this point to be a successful Chemistry 104 TA.

    a. What knowledge that you don’t already have do you feel you most need?

    b. What skills that you don’t already have do you feel you must need?

    c. Other comments on your perceived need?

8. Is there anything else that you’d like to tell us at this point in the course about your expectations or ideas?

9. Please indicate your level of agreement or disagreement with each of the following statements (circle):

	Strongly disagree		Neutral		Strongly agree
Some students will do poorly in chemistry no matter how the subject is taught.	1	2	3	4	5
As a TA, the most I can do is show students how to solve problems; the rest is up to them.	1	2	3	4	5

	Strongly disagree		Neutral		Strongly agree
Students get introduced to concepts in lecture, but is in discussion section where they really come to understand these concepts.	1	2	3	4	5
My main responsibility as a TA is to help the weaker students.	1	2	3	4	5
If students have weak math backgrounds, there is nothing much I can do for them.	1	2	3	4	5
Some students are naturally much better in a course like this than others.	1	2	3	4	5
In general, the TA has a big impact on how well students in a course like this learn.	1	2	3	4	5

10. Indicate what you think the relative importance is of each of the following possible elements of a TA's role in a course like this:

	Not important				Very Important
To translate the professor's lectures into terms students can grasp.	1	2	3	4	5
To help with difficult assignments	1	2	3	4	5
To develop students' confidence	1	2	3	4	5
To develop student's problem-solving abilities	1	2	3	4	5
To provide feedback to the professor about students' problems	1	2	3	4	5
To get students to talk about the material	1	2	3	4	5
To encourage students to work together	1	2	3	4	5
To correct students' work	1	2	3	4	5
To increase students' enjoyment of learning chemistry	1	2	3	4	5

11. Finally, please indicate how important you believe the following factors will be to students'' learning of chemistry in this course:

	not important					very important	don't know
The professor	0	1	2	3	4	5	6
The TA	0	1	2	3	4	5	6
Attending lecture	0	1	2	3	4	5	6
Attending discussion	0	1	2	3	4	5	6
"Live" chemical demonstrations in lecture	0	1	2	3	4	5	6
Video-taped chemistry demonstrations	0	1	2	3	4	5	6
Video animation of chemical concepts	0	1	2	3	4	5	6
The professor stopping lecture to allow students to discuss concepts	0	1	2	3	4	5	6