Final Report On
Evaluation of New Traditions Workshops for Chemistry Faculty:

Focus on Follow-up Surveys Documenting Outcomes for Workshop Participants

June 29, 2000

Prepared for
John Moore and Clark Landis, Co-Principal Investigators
and
Earl Peace, Project Associate Director

Prepared by
The LEAD Center
Learning through Evaluation, Adaptation and Dissemination
University of Wisconsin-Madison

Debby Penberthy and Mark Connolly

This evaluation was funded by a grant to the University of Wisconsin-Madison Chemistry department, College of Letters and Science, entitled "New Traditions: Revitalizing the Curriculum" and administered by the National Science Foundation (#DUE-9455928).

Table of Contents

I. Introduction

A. Background

The New Traditions Chemistry Project sponsored by the National Science Foundation was created to "establish and disseminate a coherently linked set of alternatives to the format of conventional chemistry education."[1] In 1997, the New Traditions faculty began the dissemination aspect of their project by holding workshops for chemistry faculty from institutions outside the NT consortium. In 1999, the New Traditions Leadership Team, the National Visiting Committee and the New Traditions Faculty agreed that the project should use faculty development workshops as the primary strategy for dissemination of the NT teaching and learning innovations. In the fifth year of the grant (1999-2000), dissemination through the NT workshops was the primary objective of the project. To date, the NT project has conducted a total of 15 workshops for more than 350 chemistry faculty from 149 different institutions.

The goals of the workshops were as follows:

- to motivate faculty to change their teaching style by convincing them that, "a) their current approach is not yielding the desired result(s) and/or b) that the "new" approach will produce "better" results;[2]
- to effect actual change in faculty teaching practices (adaption of particular NT-type innovations such as ConcepTests and inquiry-based labs)

The NT Leadership Team decided in 1997 that the preferred method of dissemination was faculty development workshops with ample time for "hands-on" development of teaching and learning strategies. Their theory was that faculty who were interested in changing their pedagogy would be more likely to be convinced to do so by the opportunity for hands-on practice with innovations than through other professional development activities (e.g., reading journal articles, listening to talks at meetings, reading web sites, etc.). The workshop organizers also theorized that faculty would be most convinced to change their practice if they had the benefit of other faculty who had positive experiences with the innovations. Thus, the workshops were facilitated by faculty who had had successful experiences with the NT-type innovations.

Workshops were scheduled for weekends, typically with faculty arriving early Friday afternoon and leaving by 4:00 p.m. on Saturday. They were conducted at host colleges and universities in locations around the country (15 states to date). Invitations were mailed to department chairs at colleges and universities within a four-hour driving radius of the host institution. Chemistry faculty from these colleges and universities were encouraged to attend as teams (three people minimum), although individuals were accepted. The team concept was intended to provide moral and professional support to innovators and enhance the chances that the climate for innovation would persist and grow.

---

[1] Report to the New Traditions National Visiting Committee-April 15, 2000, Section III, pg. 1.
[2] Report to the NT NVC-April 15, 2000, Section V, pg. 1.

As conceived by the workshop organizers, the key features of the workshop design were as follows:

- a focus on promoting incremental pedagogical change, i.e., in theory, NT-type innovations can be adapted gradually, piece by piece, with a range of innovations from those that are relatively easy to adopt/adapt (e.g., ConcepTests) to those that require systemic change (lectureless chemistry);
- a hands-on approach that allows faculty to "'try the innovations on for size" and measure the fit with their individual teaching and learning styles; and
- a structure that allows ample time for informal discussion and brainstorming among participants and organizers.

See Appendix A for a sample workshop agenda.

In the Spring of 1998, the LEAD Center, with input from the evaluators from the other NSF-sponsored chemistry consortia, designed a plan to evaluate the workshops. The evaluation plan that was carried out is described below. LEAD has been evaluating the workshops for two related purposes: (1) to provide feedback to the organizers and presenters so that subsequent workshops will be as effective as possible (i.e., formative feedback), and (2) to report to the stakeholders on the degree to which the workshops effect change among chemistry faculty, particularly whether the workshops help faculty adopt or adapt active learning strategies (i.e., summative feedback).

This is the final report on the NT workshop evaluation. It focuses on the impact of the workshops (purpose 2 above) as documented through a follow-up survey administered to workshop participants. This report also includes some summary analysis of the formative information gathered prior to and immediately following the workshops. The broader purpose of this report is to provide an example of in-depth evaluation of workshops as a method of dissemination of higher education reform efforts.

B. Research Questions and Methods

1. Research Questions

The primary research questions guiding the workshop evaluation are as follows:

> ***a. Formative Feedback on the Workshops*** What do the participants feel they gained from each session and from the workshop overall? What changes or modifications need to be made to improve particular sessions and the workshop overall? In particular, in what ways do logistical aspects contribute to or deter from the effectiveness of the workshop?
>
> ***b. Outcomes for individual attendees:*** What is the impact of the workshop on attendees as individuals? In particular, what is the short-term impact of the workshops? What new pedagogical/curricular changes are faculty *planning* as a result of the workshop? What is the long-term impact? Specifically, how, if at all, does it change their classroom practice

(e.g., use of ConcepTests, Challenge Problems, Inquiry-based Labs, UW GenChemPages and other NT-type innovations)? From the faculty's perspectives, how successful are their implementations of these changes and how do the changes affect their students?

c. Broader impact: What is the impact of the workshop on colleagues and/or departments of workshop participants? In particular, do the teams work together to create change?[3] Are there non-attending faculty members who adapted/adopted NT-type methods or were otherwise affected by the workshops?

***d. Workshops as a part of a broader faculty assistance plan*:** What barriers, if any, exist to creating change or creating it at the rate that faculty would desire? What kind of continuing assistance, if any, do the workshop participants need to make changes?

As explained below, due to the efforts required to achieve a reasonable response rate to the follow-up survey instrument, we had to reduce the scope of the evaluation. With input from the NT PIs we decided to focus on the question of impact on individual attendees and reduce our focus on broader impact and workshops as a part of a broader faculty assistance plan.

2. Methods

The research design includes the use of the following survey instruments (See Appendices B and C for examples of these surveys):

1) *Pre-survey* to explore participants' goals, expectations and backgrounds;
2) *End-of-workshop survey* designed to obtain immediate feedback on the workshop and attendees' perceptions about changes that, as a result of workshop attendance, they were intending to make; and
3) *Follow-up survey* administered through the web and e-mail one semester to two years after workshop attendance and designed to document self-reported changes in classroom practice due to the workshops.

Below, we discuss important issues in data collection and analysis for the surveys listed above, including survey response rates.

a. Pre- and End-of-workshop Surveys

The pre- and end-of-workshop surveys were revised several times to streamline analysis. In general, revision entailed using open-ended comments from the earlier workshop surveys to create categories for forced-choice questions to be used on subsequent workshop surveys. For instance, from analyzing the comments regarding suggestions for improvements to the workshops and open-ended comments about the workshop in general, we developed a set of factors that seemed to contribute to the degree of workshop success. This set of factors was then used in a table on the end-of-workshop survey to gather more systematic input on this issue.

[3] The NT workshops are designed for teams of faculty from the same institutions to attend and, by the end of the workshop, develop a plan for change.

The pre- and end-of-workshop surveys were administered at all but one of the NT workshops held between April 1998 and March 2000. The response rates to the pre- and end-of-workshop surveys were high, with an overall response rate of 80% (176/221 participants) for the pre-surveys and an overall rate of 78% (181/231) for the end-surveys. In Table 1, below, we present the number of attendees and response rates for the workshops that were conducted prior to the year 2000. Note: Pre- and end-surveys were gathered at the workshops conducted in 2000 (three so far), but these data will not be analyzed by the LEAD Center to allow for time to complete this project.

Table 1.
Pre- and End-of-workshop Survey Response Rates

Report #	Date and Place of Workshop	Attendees	# Pre-svys	Pre-svy Rate	# End-svys	End-svy Rate	# with Both Pre- and End-Svy[4]	Response Rate for Both Surveys
1	University of Wisconsin (Madison), Apr-98	43	43	100%	39	91%	37	86%
2	Santa Fe Community College (Gainesville, FL), Oct-98	23	18	78%	15	65%	12	52%
3	Wartburg College (Waverly, IA), Oct-98	10	N/A[5]	N/A	9	90%	N/A	N/A
4	Towson U (MD), Mar-99	24	18	75%	15	63%	9	38%
5	Texas A&M U (College Station), May-99	31	26	84%	27	87%	24	77%
6	San Jose State U (CA), Jul-99	22	20	91%	19	86%	17	77%
7	Edinboro U of PA, Sep-99	23	17	74%	22	96%	15	65%
N/A	Ashland U (OH), Oct-99	26	19	73%	17	65%	14	54%
N/A	Norfolk State University (VA), Oct-99	29	15	52%	18	62%	11	38%
Totals and Overall Response Rates		**231**	**176**	**80%***	**181**	**78%**	**139**	**63%***

* Percentage calculated based on the number of attendees who received the pre-survey (221).

Utility of Surveys

The LEAD Center produced 7 individual reports on NT workshops based on the pre- and end-of-workshop surveys. These reports were used by the organizers to inform subsequent workshops and to give real-time feedback on the success of the workshops as a method of disseminating the NT reforms. Example reports may be obtained by contacting the LEAD Center.

In addition, the workshop organizers used the pre-surveys to tailor their agendas to the interests of the participants. In particular, the pre-survey was designed to gauge the participants' experience with each of the innovations that appeared on the workshop agendas. During the introduction to the workshops, the organizers collected and reviewed the pre-surveys. If, for example, most of the participants indicated some experience with the use of guided-inquiry or discovery labs, the organizers used this information to consider omitting that portion of the workshop and distributing the additional time to other topics. Also, if all of the participants

[4] This column presents the numbers of individuals who completed both the pre- and end-surveys at each workshop.
[5] Because this workshop was only three hours long, pre-surveys were not administered.

represented institutions that did not employ teaching assistants, the TA-training session was omitted.

b. Follow-up Survey

In the summer of 1999, we first administered our web-based version of the NT Workshop follow-up survey to all participants of the four early workshops held between June, 1997 and June, 1998. (This included participants from the first two NT workshops, conducted prior to the LEAD Center's evaluation.) In late January, 2000, we surveyed the participants of the eight later workshops held between October, 1998 and October, 1999. In total, we attempted to reach 297 of the 303 participants (e-mail addresses for six of the participants were unavailable).

The web-based survey was developed with input from the NT workshop organizers, the National Visiting Committee, and the NT Leadership Team and piloted with a few workshop participants. It was a lengthy survey that attempted to elicit detailed information about the types of changes and collaborations participants had engaged in after and due to the workshops. It was administered by requesting participation over e-mail and directing respondents to the survey, which was located on the commercial web site, Flashbase (http://www.flashbase.com). This was essentially an experiment, as no other NT survey instruments had been administered using the web.

We encountered several difficulties with the web-based survey, including respondents encountering problems accessing the survey through the web site and the fact that only 279 of the e-mail addresses on record for the participants were functioning (i.e., eighteen of our messages were undeliverable). Because of the nature of e-mail communication, we can also assume that a few of the other messages were not received. For these reasons, and possibly others, the response rate for the web-based survey was quite low. As of mid-February, after the LEAD Center and the NT grant administrator, Earl Peace, had sent multiple pleas for participation, we had received only 75 responses. Using the 279 ostensibly reachable participants to calculate the response rate, the response rate to the Flashbase survey was 27%.

Because we considered this response rate too low, we devised a plan to raise the response rate. We hypothesized that two factors had caused the low response rate to the web-based survey: (1) the length and complexity of the survey and (2) the multi-step process required for participation that included reading the e-mail message asking for participation, linking to the web site, logging into the survey and completing the survey. Based on these assumptions, we shortened the survey to focus primarily on the main research question, i.e., the changes in classroom practice that resulted from workshop participation. We also administered the survey through e-mail. On March 7, 2000, this modified survey was administered on e-mail to all of the participants who had not yet responded. This strategy was successful, as it doubled the response rate, resulting in 146 respondents for 52% of our reachable population responding. (Note: if including those who were unreachable, this constitutes 46% of the total number of participants for these workshops.)

Utility of Survey

The follow-up survey will be used to evaluate the effectiveness of the workshops as a dissemination strategy and to inform modifications to the content and structure of future

workshops. In addition, the leaders of the recently funded NSF "Multi-Initiative Dissemination Project" will use the LEAD Center survey instruments as a template for future workshop evaluation efforts.

C. Notes to the Reader

1. Verbal Quantifiers

Specific verbal quantifiers are used to denote the relative size of a group of participants 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 who *discussed* a particular type of experience does not indicate the size of the group who *had* this type of experience. Although the same interview protocol was used in each interview, respondents' answers often prompted discussion in 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 under consideration

"many":
used when 30 to 70% of those interviewed presented the perspective under consideration

"most:"
used when 70 to 90% of those interviewed presented the perspective under consideration

"virtually all:"
used when 90 to 100% of those interviewed presented the perspective under consideration

2. Analysis of Open-ended Questions

Many of the questions on the NT workshop evaluation surveys were open-ended, i.e., instead of responding to pre-formulated choices for these items, participants answered in their own words. The researchers used an inductive process to analyze the open-ended responses. After first reading through all of the responses, they developed codes by identifying common types of answers and assigned these codes to the answers. Multi-faceted responses were given more than one code.

Interpretation of the number of people giving particular responses to open-ended questions requires a different framework than for forced-choice questions. First, for open-ended questions the number of people giving a particular response is not necessarily the same as the percentage who hold this opinion. It is simply the number who *mentioned* it. Thus, it is reasonable to assume that often the number of people holding this opinion may be greater than the number who gave it as part of their answer. Second, because many responses were given more than one code, the total number of responses for each of the open-ended questions exceeds the number of survey respondents. The response categories are not to be interpreted as mutually exclusive.

II. Data Analysis

Below we present analysis of key survey questions from the NT workshop surveys.

A. Pre-workshop Surveys

The pre-workshop surveys asked many questions about participants' incoming characteristics and interests. Analysis of responses to all pre-survey items can be found in Workshop Reports 1-7. Here, we present analysis of key questions from this survey.

One of the workshop organizers' strategies was to recruit attendees who were interested in the types of innovations NT was promoting, in order to increase the likelihood that the workshops would create change. This strategy is consistent with the literature on dissemination. One indicator of whether or not this strategy was carried out is the percentage of attendees who had experience with active learning and their ratings of success with using active learning strategies. In Tables 2 and 3, below, we present the aggregate data on this question from the pre-surveys. These data suggest that the organizers were successful at recruiting a majority of attendees who have interest in and experience with active learning. As shown in Table 2 (below), the majority of attendees (69%) were experienced with active learning.

Table 2.
Pre-workshop Experience with Active-learning Strategies

Response	***n***	**Percentage**
No	54	30.7%
Yes	121	68.7%
Undecided	1	0.6%
Total	**176**	**100.00%**

As shown in Table 3 (below), of these participants, most were positive or neutral in rating the success of their efforts to use active learning in their classes.

Table 3.
Pre-workshop Success with Active Learning

Rating (5 = high)	*n*	Percentage
5	10	11%
4	31	35%
3	38	43%
2	4	4%
1	0	0%
No response	6	7%
Total	**89**[6]	**100%**

B. End-of-workshop Survey

The ultimate impact of the NT workshops is best assessed by the follow-up survey, as it documents self-reported changes actually made by faculty as a result of the workshop. Additionally, the end-of-workshop surveys provide important outcomes information about the potential impact of the workshop and participants' perceptions of the value of the workshops. Below we present analysis of four key aspects of the end-of-workshop surveys:

- participants' plans to change classroom practice as a result of the workshops;
- participants' plans to collaborate with others to make NT-type changes;
- participants' overall ratings of the value of the workshops; and
- summary of feedback on strengths and weaknesses of the workshops.

1. Plans to change classroom practice as a result of the workshops

On the end-of-workshop surveys, faculty were asked whether they planned to change their teaching practices as a result of attending the workshops. As shown in Table 4 (below), most of the respondents (88%) were planning to make such changes.

[6] Note: On the first workshop survey, this question was asked in an open-ended form, not with a Likert-type scale. Thus, these responses are not included in this question.

Table 4.
Participants' Plans to Change Teaching Practices

Response	*n*	Percentage
Yes	159	88%
No	6	3%
Undecided	9	5%
No Response	7	4%
Total	**181**	**100%**

Also on the end-of-workshop survey faculty wrote in the types of changes they were planning to make and specified whether this constituted first-time use or increasing or refining their existing practice(s). Table 5 (below) presents these numbers. This table was developed by coding open-ended responses on the end-surveys from the ten workshops listed in Table 1. Because pre-formulated choices were not provided on the survey, there may have been more faculty who were planning to utilize particular ideas presented in the workshop, but who did not mention this on the survey.

The four innovations that appeared most often on the workshop agendas were ConcepTests, Inquiry-based Labs, Challenge Problems and UW GenChemPages. As might be expected these innovations were generally cited most often by faculty as being those they planned to adapt. The numbers of end-survey respondents who planned some level of change (first-time use, refinement, or increased use) in relation to these innovations are as follows:

ConcepTests: 116 (64% of the 181 end-survey respondents)

Inquiry-based Labs: 62 (34%)

Challenge Problems: 36 (20%)

UW GenChemPages: 2 (1%)

Table 5.
Participants' Planned Teaching Innovations and Levels of Use

Types	Innovations	New	Refining, Increasing	Unclear[7]	Total[8]
Lecture-based	**ConcepTests**	**50**	**65**	**1**	**116**
	Challenge problems	**20**	**16**	**0**	**36**
	Other active learning strategies	6	3	0	9
	Lectureless classes	1	1	0	2
	MathCad	0	1	0	1
Lab-based	**Inquiry-based labs**	**29**	**32**	**1**	**62**
	Organic chemistry modifications	1	2	0	3
	UW GenChem pages	**2**	**0**	**0**	**2**
	Pre/post lab questions	0	1	0	1
	Linking lab and lecture	0	1	0	1
General	Inquiry-based learning	11	10	0	21
	Group/collaborative work	5	15	0	20
	Other active-learning strategies	3	12	1	16
	Use of modular chem innovations[9]	7	3	0	10
	Innovative assessment & evaluation strategies	6	3	0	9
	Use of Internet-based resources	5	0	0	5
	Thematic teaching	2	0	0	2
	Revision of curriculum topics	0	2	0	2
	TA training	1	1	0	2
	Working to promote faculty change	0	0	2	2
	Philosophy change	0	1	0	1
Other		1	1	0	2
Totals		**150**	**170**	**5**	**325**

[7] During the first workshop that was evaluated by the LEAD Center, participants were asked to indicate what types of changes they were planning to make, but were not asked to specify whether this constituted first time use or a refinement of their pre-existing practices. Thus, we coded these responses with regard to the level of change. However, some of these responses were sufficiently unclear that we decided to categorize them as such.

[8] Because in a few instances variations of the same general innovation were mentioned more than once by the same participant, the total number of "mentions" is not in all cases equivalent to the total number of participants who planned some level of change with the innovation. However, in the case of the four innovations in bold typeface, the mentions are equal to the number of participants planning change relating to the innovations.

[9] These mentions came from surveys from the workshop held at SJSU, which was a collaborative project involving three NSF-sponsored chemistry curriculum initiatives: New Traditions, ChemLinks, and Modular Chemistry.

2. Plans to collaborate on NT-type innovations

When asked whether they planned to collaborate with other faculty or staff to use of the ideas presented during the NT workshop, most end-survey respondents (76%) said yes (Table 6 , below).

Table 6.
Participants' Plans to Collaborate

Response	Total	Pct.
Yes	138	76%
No	9	5%
Undecided	24	13%
No response	10	6%
Total	**181**	**100%**

3. Participants' rating of the overall value of the workshops

In general, the workshops were well received by the majority of participants. For the question asking participants to rate how much they gained from the workshop overall using a scale of 1-5 with 5 being the highest, the weighted average was 4.1, and the range of average ratings for individual workshops was 3.7-4.6 (Table 7, below). In addition, as shown in Table 8 (below), most of the survey respondents (77%) gave the workshop one of the two highest possible ratings (4-5). The open-ended comments about the benefits of the workshop and data points two and three above are consistent with these high ratings.

Table 7.
Overall Gains of Participants from Workshops

Workshop Location	Average	*n*
Wartburg College, Waverly, IA (Oct-98)	4.6	9
Towson U, MD (Mar-99)	4.5	14
Ashland U, OH (Oct-99)	4.3	16
Santa Fe Community College, Gainesville, FL (Oct-98)	4.2	13
Texas A&M U, College Station (May-99)	4.2	25
Norfolk State University, VA (Oct-99)	4.2	17
San Jose State U, CA (Jul-99)	4.1	14
U of Wisconsin-Madison (Apr-98)	3.9	32
Edinboro U of PA (Sep-99)	3.7	21
Weighted Average and Total Responses	**4.1**	**161**

Table 8.
Frequency of Ratings of Overall Value

Response	# of Respondents	Percentage of Total Respondents to End-svy N=181
1	0	0%
2	2	1%
3	20	11%
4	97	54%
5	42	23%
Blank	20	11%
Totals	**181**	**100%**

4. Summary of feedback on strengths and weaknesses of the workshops

Feedback on the strengths and weaknesses of particular workshops was gathered through multiple questions on the end-of-workshop surveys. This feedback has been presented to the NT organizers in Formative Feedback Reports 1-7. Below we summarize key points from this feedback.

a. Strength of hands-on approach

As illustrated by the following quotes, the hands-on nature of the workshops was mentioned by many participants as one of the most valuable aspects of the workshop.

> We got involved in activities and discussions. We didn't just sit back and listen. Many practical examples were given.
>
> I really enjoyed the workshop as an opportunity for me to learn about new teaching methods. I especially appreciate the hands-on format and the possibility to see things that could be adopted fairly easily in our program.
>
> I liked the fact that you made us work instead of talking at us.

The hands-on approach seemed to make it more likely that participants would take those innovations back and try them in their classrooms and laboratories. This point is consistent with the fact that, at the end of the workshops, most of the attendees indicated that they would make changes to their classroom practice based on the workshop.

b. Need for more depth on specific innovations

Some workshop participants felt that even more time could have been devoted to working hands-on with development of specific innovations. In particular, some wanted more time to write and evaluate ConcepTests and Challenge Problems and more time to revise standard labs to make them into inquiry-based labs. In addition to needing more time on these innovations, some participants needed more guidance on developing their own versions of these innovations.

c. Informal workshop format that allowed for ample discussion time

The informal nature of the workshops and the frequent opportunities for discussion among participants and attendees was generally considered a strength. Participants who commented on what they had gained from the workshop (on a specific question from the end-of-workshop survey) frequently mentioned that they valued meeting their colleagues from around the region who were also interested in active-learning and exchanging ideas and experiences with them. Some workshop participants felt that there could have been even more time for this type of interaction. The one workshop that was held at a residential conference center with centralized facilities for meeting and lodging provided additional opportunities for informal interactions among participants outside of scheduled workshop time. Participants at this workshop indicated that this was very valuable.

d. Strength and weakness of multiple innovations covered in weekend workshop

The fact that the workshops contained many short sessions on several different NT-type innovations was viewed as a strength and a weakness. For several workshops, a number of people commented that the pace of the workshop was too fast and that there needed to be more depth on specific innovations; it is reasonable to assume that the fast pace was due to the fact that the workshop was designed to cover multiple innovations. However, as in the following quote, others commented that they liked the fact that the workshop covered many different things and that they could pick and choose from the innovations.

> I liked the way that ideas were presented as a series of things to try. Take what you want, buffet-style workshop, is wonderful!

The strength of this approach is also borne out in the range of innovations that faculty, at the end of the workshop, intended to try in their classrooms. Ultimately this feedback suggested to the evaluators that there might be a need for two different types of workshop, one with many short sessions addressing a variety of teaching and learning innovations in one weekend, and another that focuses on fewer innovations in more depth over the same time period.

d. Good size for workshop group

In general, workshop participants felt that the size of the workshop group, which averaged around 25 participants, was optimal. Their feedback suggested that the workshop group was small enough that it allowed for meaningful interactions with many of the participants.

f. Good length and timing of workshop

In general, workshop participants felt that the workshop was a good length and that the weekend schedule was conducive to their being able to participate. As one participant commented,

> I'm very pleased to have been allowed to come. The time is excellent. I am not distracted by the teaching load or admin. duties. This was very refreshing and intellectually stimulating. Thanks very much for doing this.

C. Follow-up Survey Analysis

The follow-up survey was designed to document the outcomes for faculty as a result of attending the workshop. In addition, it contained questions on other benefits, faculty views on the success of their implementation of chances and the effects on students, participants' efforts to collaborate to make NT-type changes, and feedback on the strengths and weaknesses of the workshops. Below, we present analysis on each of these issues.

1. Outcomes of workshop attendance

Below we present analysis of information on the outcomes for workshop attendees as a result of participation in the NT workshops.

a. Effects on faculty

The primary question answered in this report is how many of the survey respondents reported that they benefited from the workshop. People who benefited from the workshop were defined as anyone who indicated that they had done or experienced at least one of the following:

- began or modified one or more of the 17 different NT-related innovations mentioned on workshop agendas and included as choices on the forced-choice questions on the web-based survey;
- made some pedagogical change, but not with regard to any of the 17 NT-related innovations mentioned above, as a result of the workshop; and
- experienced some other kind of benefit of attending the workshop.

Analysis for the above question was based on multiple survey items from the web and e-mail surveys. The analysis revealed that virtually all of the workshop participants who responded to the survey (134/146, or 92%) reported some benefit from attending. Below we explain how we arrived at this figure.

The number of workshop participants who enjoyed some kind of benefit from attending the workshop was calculated by subtracting the number of participants who met none of the above three criteria from the total number of survey respondents.

Of the 146 survey respondents--

- 109 began or modified one or more of the 17 different NT-related innovations mentioned on workshop agendas; 37 did not.
- Of these 37, five changed their teaching using only pedagogical method(s) that were not among the 17 NT-related innovations included as forced-choice options on the web-based survey, but were nonetheless acquired from attending the workshop.

Therefore, based on responses from workshop participants, 114 faculty changed their teaching as a result of attending the NT workshops, and 32 workshop participants did not benefit from the workshop through changes in their teaching.

- Of these 32, 20 reported a type of benefit other than "changes in their teaching," such as an opportunity to network with other faculty.

Thus, there were only 12 respondents who reported none of the above three benefits. Virtually all of the respondents (134/146, or 92%) reported some kind of benefit from workshop attendance. Further, 4 of these last 12 respondents reported in the follow-up survey that they were interested in trying NT innovations in the future.

Below, we present analysis on three types of benefits that participants reported experiencing as a result of workshop attendance:

- specific pedagogical changes made to teaching practice;
- interest in making other types of changes in the future; and
- benefits other than change to teaching practice.

1) Specific pedagogical changes actually made

The 15 workshops addressed multiple pedagogical changes to classroom practice. Below is a complete list of the innovations that were included at least once on an NT workshop agenda:

- Calibrated Peer Review of Writing
- Chemlinks or MC^2 Modules
- ConcepTests

- Inquiry-based labs
- New Approaches to Evaluation and Assessment
- Thematic Teaching
- CCNY Workshop Approach
- Computer Technology to Enhance Learning
- Groupwork in Labs
- Lectureless Chemistry
- Problem-based Learning
- UW GenChemPages
- Challenge Problems
- Cooperative Learning
- Groupwork in Lecture/discussion
- Mathcad Interactive Texts
- TA Training for Active Learning Classrooms

Of primary interest to the workshop organizers was how many participants made changes to their classroom practice with regard to the innovations that were on the workshop agendas. To address this question, the web-based follow-up survey asked participants to indicate which of the above strategies they either began using or modified[10] as a result of the workshop. On the e-mail survey, an open-ended question asked respondents to indicate how, if at all, they had changed their teaching practice as a result of the workshop and whether this was a new innovation for them or they were modifying their previous practice. Most of the changes mentioned by those who responded to e-mail fit within the above categories, although a few did not, and these were coded as "other pedagogical changes."

In Table 9 (below), we present the number of respondents who reported engaging in any form of pedagogical change as a result of the workshop.

Table 9.
Number Engaging in Pedagogical Change

Made Changes?	Number	Percent
Yes	114	78%
No	32	22%
Total	146	100%

In Table 10 (below), we present the number of participants who reported making specific changes to their classroom practice as a result of the workshop.

[10] Modifications included increasing and refining usage.

Table 10.
Changes by Innovation

Type of Innovation	Number Who Increased, Refined	Number Who Started	Total	Percent of Total Respondents to Survey (n=146)	Percent of Those Who Made Changes (n=114)
ConcepTests	31	45	76	52%	67%
Groupwork in Lecture/discussion	29	9	38	26%	33%
Inquiry-based Labs	20	16	36	25%	32%
Cooperative Learning	23	10	33	23%	29%
Challenge Problems	6	22	28	19%	25%
Computer Technology to Enhance Learning	13	4	17	12%	15%
Groupwork in Labs	14	3	17	12%	15%
New Approaches to Evaluation and Assessment	5	4	9	6%	8%
Problem-based Learning	5	3	8	5%	7%
Lectureless Chemistry	3	4	7	5%	6%
Calibrated Peer Review of Writing	0	4	4	3%	4%
Thematic Teaching	0	4	4	3%	4%
Chemlinks or MC^2 Modules	0	2	2	1%	2%
TA Training for Active Learning Classrooms	2	0	2	1%	2%
UW GenChemPages	1	1	2	1%	2%
CCNY Workshop	1	0	1	1%	1%
Mathcad Interactive Texts	1	0	1	1%	1%
Other Pedagogical Changes	8	2	10	7%	9%

Explanations for "why no changes made"
As stated above, 32 (22%) of the workshop participants did not report making any changes to their classroom practice due to the workshop. A number of follow-up survey items gathered information about why these workshop participants did not change their teaching practices. Our analysis of these data reveals the following principal reasons why these participants did not change: (1) they were already using NT-like innovations, or (2) they had not yet had the opportunity to teach a class in which NT-related innovations could be tried out. Other, less common reasons given for not changing one's teaching included lacking will to change, having too little time, facing student resistance, and lacking evidence of effectiveness of NT-related innovations.

2) Changes to pedagogical practice that respondents would like to try

Data from the web and e-mail surveys indicated that a number of workshop participants had interest in making pedagogical changes they had not yet attempted (see Table 11, below). It is important to note that, because in some instances, respondents expressed interest in NT-related innovations not covered in the workshop they attended, this interest was not in all cases a benefit of workshop attendance.

Table 11 .
Innovations that Workshop Participants Would Like to Try

Type of Innovation	***n***	**Pct. of all respondents (N=146)**
New Approaches to Evaluation and Assessment	17	12%
Inquiry-based Labs	14	10%
Chemlinks or MC2 Modules	13	9%
Calibrated Peer Review of Writing	12	8%
Challenge Problems	11	8%
Thematic Teaching	11	8%
Lectureless Chemistry	9	6%
Problem-based Learning	8	5%
TA Training for Active Learning Classrooms	8	5%
CCNY Workshop	7	5%
Mathcad Interactive Texts	6	4%
Computer Technology to Enhance Learning	5	3%
ConcepTests	5	3%
Cooperative Learning	5	3%
Groupwork in Lecture/discussion	5	3%
UW GenChemPages	4	3%
Groupwork in Labs	2	1%
Other	2	1%
Total	**144**	**100%**

3) Other benefits

The web and e-mail surveys asked participants to indicate whether they had benefited from a workshop in ways other than changing their classroom practice and, if so, to describe these other benefits. Analysis of these items revealed that many workshop participants enjoyed benefits other than changing their teaching practice.

Below we discuss these benefits by analytical category.

a) Gaining teaching insights and changing teaching philosophy

One such additional benefit was gaining important teaching insights. For example, some faculty indicated that, from attending the workshop, they learned more about techniques and teaching-related issues.

> Through this workshop and others, I have a better appreciation of the advantages and disadvantages of inquiry-based approaches in lectures, labs, and recitations.
>
> I think the NT workshop provided another perspective from which I could increase my awareness of my classroom dynamics.
>
> In general I think I better understand the plight of the commuter student.
>
> Whenever possible, I try to engage the students in the learning process, to take an active role in their education.
>
> Even though I cannot be specific and name one particular technique and report that it is successful, instead I can say that I think the workshop improved my teaching effectiveness and it was time well spent on my part.
>
> Perhaps most importantly, the workshop did help to heighten my sensitivity to different learning styles. I find that I now tend to place more responsibility on myself to adapt to my students rather than the reverse.

A number of faculty mentioned that attending the workshop had influenced their teaching philosophy.

> [It was a benefit to me] trying to see chemistry from the learning perspective rather than the teaching perspective.
>
> I focus less upon how I can improve my performance in the classroom and more upon how I can get the students to improve their performance. I realize they are intimately related; however, they are not identical.
>
> [A benefit to me was] stronger emphasis on student-centered, hands-on, minds-on learning experiences.

> My philosophy and approach to teaching began before the NT workshop, and it just convinced me that I was on the right track and only needed to do more and try to be more innovative.

b) Collegial networks

In addition to gaining insights that extended their understanding of teaching, another important benefit was the collegial networks it offered to participants. Numerous workshop participants remarked how helpful it was to share ideas with like-minded faculty.

> The main benefit that I received was the stimulation of being around other people who are also trying hard to improve college instruction in the area of chemistry. This was encouraging. I came away feeling (a) there are a lot more people out there trying new things than I realized, and (b) that we are on the right track with some of our local initiatives. But, participation in the conference did not significantly change our local initiatives.

> I am continually changing my style and refining it. Every time I interact with other educators I get ideas.

> It is always refreshing and re-invigorating to discuss teaching techniques and problems with other college instructors. The exchange of ideas in the brainstorming session was terrific.

> It was good to meet other people and hear what they are doing. It always helps me to get more ideas.

> Very helpful to meet other college chemistry teachers whom I do not ordinarily see.

> [It was beneficial to realize] that there are others who are looking for better and more effective ways to present chemistry and encourage students to participate in and take responsibility for their learning.

> Opportunity to meet and talk with faculty who are trying out new techniques, get advice, and encouragement from others in the same situation.

> Sharing teaching problems with other teachers was the greatest benefit.

> One benefit was to talk with people who are more deeply involved with the educational literature than I. I found the informal discussion valuable as well as the formal ones.

c) Increased enthusiasm for use of active-learning methods

For numerous participants, a third benefit, closely related to the interactive nature of the workshops, was a boost to their enthusiasm for, and confidence in, using both new and current active-learning approaches.

> I am more confident in the decisions I've made as an instructor. I feel affirmed when institutions such as UW-Madison are using similar strategies.
>
> [I am] more excited about using some of the changes discussed in the workshop.
>
> I become more motivated to use this more difficult teaching strategy consistently in the classroom.
>
> It reinforced my belief that I am only a guide in [the students'] educational process.
>
> The workshop affirmed many of the practices and approaches I have been using.
>
> The workshop did not change the way I teach. However, it validated many techniques that I used as part of my natural teaching style.
>
> I am more self-assured in implementing changes in the curriculum regardless of whether others in the department want to follow along. I do not think I could go back to straight lecturing.
>
> I was really re-vitalized by the workshop, which gave me a professional "high" for several months.

d) Opportunity to reflect on teaching and learning

Another benefit of the workshop was the opportunity it afforded workshop participants to reflect on teaching and learning. A number of participants enjoyed the opportunity to think about one's own practice and to talk with thoughtful colleagues about teaching and learning.

> It was good to participate in a program that made me think a little more about my teaching methods. Programs such as this serve to rejuvenate those of us who have been in the business a long time.
>
> Stimulated my thinking about use of instructional software, student e-mails, and group work in laboratories.
>
> [Another benefit was] time spent thinking about teaching and learning.

Two participants commented that the workshop gave them reason to believe in the effectiveness of the NT-related innovations. For example, one respondent wrote, "This was an educational experience for me from the viewpoint that it seems so successful with a wide variety of students with different backgrounds."

b. Faculty views on effects on students

The ultimate goal of the NT workshops was to have an impact on the student learning experience through effecting change in instructors' classroom practice. As such, both versions of the follow-up survey asked faculty to comment on how, if at all, the changes that they made to their classroom practice as result of the workshop affected their

students, particularly in terms of attitudes, motivation, and learning. Below we present an analysis of these open-ended questions. First, we present quantitative data gathered only on the web-based survey.

On average, respondents agreed with the statement, "The changes I made seemed to greatly increase student effort, participation, and/or motivation." Respondents rated their agreement or disagreement with this statement using a 7-point scale where 1 equaled "Strongly Disagree," 4 equaled "Neutral" and 7 equaled "Strongly Agree." The average response was 5.1, and most (76% or 52/68) gave positive responses (ratings of 5-7). However, the most common response was a rating of 5, given by 28 of the 68 respondents to the question (41%).

A similar pattern appeared in responses to the question asking participants to indicate the degree to which they agreed or disagreed with the statement, "The changes I made to my classroom practice greatly increased my satisfaction with my students' learning." Using the same 7-point scale, the average response was 5.0, and the majority of participants (74%, or 50/68) gave positive responses (5-7). Again, the most common response was a 5, given by 31 of the 68 respondents to this question (46%). Responses to both of these questions suggest that, although the changes that the respondents to the web-based survey made to their classroom practice positively affected the students, it did not have strong effects.

Analysis of open-ended comments on effects on students:

Because most workshop participants who responded to our surveys did not have systematic measures of student outcomes related to NT-type changes, they tended to report effects on students by using their first-hand observations of learning processes. As with data from other open-ended survey items, thematic analysis produced general categories that summarized workshop participants' descriptions. Based on the responses to four survey items, faculty reported that students in classes using NT-related innovations were generally affected in the following ways.

1) Increased engagement in learning activities.

When describing the implementation and outcomes of NT-related innovations, workshop participants mentioned most often that students were more involved and motivated in their classroom and lab activities. A significant number of faculty described observable changes in student behaviors that reflected increased engagement.

> [The students] tended to stick around for the entire lab period, whereas before they grabbed the data and ran!
>
> I was surprised how I never ended the class on time. [The students] always made me stay with their questions. The biggest change was that previously people stopped showing up halfway through the course, but this year the lectureless lecture room was packed. I still cannot believe it.

> Peer teaching and buy-in to chemistry increased. Students reported they liked it better. I saw improvement in class attendance and retention of students as well as understanding of the material.
>
> The students often ask for more in class working sessions, so they seem to prefer them, too.
>
> Better lecture attendance, slightly better exam performance.
>
> I have found that the students are more involved in the learning process. . . . They are less likely to sleep, read the newspaper, etc. (I regularly teaching in a large auditorium with approximately 300 students.)
>
> More actually came prepared in class. Motivated not to sleep in class.
>
> They were more engaged in the learning process and took more responsibility for learning the material.
>
> Seemed to be effective in engaging students and promoting better learning.
>
> Our students find cooperative education projects very rewarding. I believe that it improves both their confidence in the material as well as their enjoyment. I also believe that it improves retention and depth of understanding.
>
> They are much more engaged. Overall, they are very turned on to lab and to figuring out what is going on.
>
> My feeling is that all the innovations have helped student attitudes, motivation, and learning.
>
> I started using ConcepTests after I attended the UW-Madison NT workshop, and I believe it has enhanced my students' attitudes and motivation for wanting to learn chemistry.
>
> Increasing cooperative learning especially thematic and using topics of current interest definitely motivates the student. They become excited about the topic and are eager to share what they have learned with others.

A significant number of workshop participants who indicated that NT-related innovations improved student engagement qualified their answers by explaining that the innovations did not work equally well with all kinds of students in all settings. For example, one participant said,

> Effects on [student] attitudes are uneven; some students really like them, while others, often better students, seem to feel they do not need to do this type of work because they already "know" the material. Consequently, the less able students often do better because they take the group work seriously.

Another respondent made a similar comment:

> The students who seem to thrive in the group-learning situations are the weaker students who are highly motivated and like talking problems over with someone else.

2) Increased student satisfaction with course experiences

When appraising the effects of NT innovations on their students, many faculty noted positive changes in their students' satisfaction with the learning environment.

> Students love the computer accessibility of course material.

> The ConcepTests allow the students to quickly affirm information and to learn from their peers. I think that the students like this in that it breaks up the lecture a bit and challenges them.

> ConcepTests were rated highly by the students in surveys we have done.

> My students like the in-class activities and seem to be better prepared.

> Students usually seem to like [group projects] and it expands their learning of the material.

> Students like group work and claim to learn more.

> My students enjoy [ConcepTests], and I have a better understanding of where they are.

> I think, overall, the student enjoy having more control over what they are doing in the lab.

As when describing effects on students vis-à-vis student engagement, a number of survey respondents remarked that not all students were equally satisfied with how NT-related innovations changed their learning experiences. A number of responses indicated that some students who resisted teaching methods that differed from those with which they were already familiar were quite dissatisfied with these changes. For example, one participant replied,

> Most students liked the new approach, but a few wanted lectures, feeling that they were missing something because there was no presentation laying everything out.

3) Increased student learning

As stated above, most respondents' comments about the effects on students were based on anecdotal accounts of student behavior. This was true for comments about effects on student learning as well, as most respondents did not have systematic measurements of changes to student learning outcomes. Perhaps because of this lack of assessment data, the comments from participants about effects on student learning tended to be more equivocal than their comments about other types of effects on students. Below we present analysis of comments related to this issue.

In a number of cases, faculty linked active-learning activities to improved performance on academic work (e.g., homework, in-class assignments).

> Motivation and learning have increased by making students active participants during class, rather than passively listening to lectures.
>
> Students were more active in class/lab, learned to work in groups better.
>
> I think learning has increased because the students are forced to examine recently covered material and it becomes apparent when their thinking is faulty.
>
> They are learning more as evidenced by their examination grades, they are more outgoing, both within their team and in terms of interaction with other teams.
>
> My feeling is that all the innovations have helped student attitudes, motivation, and learning. Cooperative learning helps define and legitimize students working together. It points toward their likely work experiences after college. Inquiry-based labs add challenge to the lab experience. New skills are needed to develop suitable experimental design and to interpret experimental data. Problem-based learning and thematic teaching can bring an increased sense of relevance to learning. I have used the ozone hole as a theme for dealing with chemistry of the non-metals, reaction rates and mechanisms, and science and societal issues in general chemistry this past semester.
>
> Seemed to be effective in engaging students and promoting better learning.
>
> Students find our cooperative education projects very rewarding. I believe that it improves their confidence in the material as well as their enjoyment. I also believe that it improves retention and depth of understanding.
>
> Better lecture attendance, slightly better exam performance.
>
> The more active the learning, the more the students learned and enjoyed the class.

Some workshop participants expressed effects on student learning in terms of changes in what might be called scientific thinking.

> The labs increased the use of hypothesis formation and involved greater reliance on data analysis (spreadsheets/graphing/etc.) I felt that they had a better understanding of some principles and experimentation, in general.
>
> Groupwork and Challenge Problems: For some students, it helped the student to see HOW to proceed through a problem and a solution.
>
> Challenge problems are fun to write and challenging for the students. They also help with informational literacy skills, producing better educated students.
>
> Using concept tests has required my students to understand while I am presenting it. They become more engaged with the material. . . . I also modified some of my non-major labs to be inquiry based. It really helped them see the process of science and not just something they had to do.

> Students learn more this way because they don't know the outcome from the onset.

However, a number of workshop participants expressed uncertainty about whether changes in student learning were occurring.

> The time since the workshop is not sufficient to know if the changes will make a difference in learning or student attitudes.
>
> Some students say that computer simulations and having a web page for the course helps their learning; others say it has no effect.
>
> Were you to wonder what effect these changes or increases had . . , I would say students were more responsive to group quizzes. . . . Whether they learned more cannot be assessed properly, as their performance was not quantitated [*sic*] in a before/after fashion.
>
> Some [students] seemed more motivated; however, the grades did not improve significantly.
>
> Students were surveyed at the end of each semester, and although no statistical data was collected, written comments shared by students showed improved attitudes and motivation. Overall learning effectiveness was more difficult to judge.
>
> I think the students like the change (i.e., more thinking time in class vs. pure lecture time). I'm not sure it makes much difference in learning.
>
> I'd say it helped their motivation and attitude, but I am not as certain about their learning.

Summary

In summary, a significant number of workshop participants reported that NT-related innovations positively affected their students' engagement in educationally purposeful activities, satisfaction with their learning experiences, and learning outcomes. However, most workshop participants lacked the kind of data that would allow them to make stronger inferences about how the innovations affected the learning processes and outcomes. This lack of data seemed to affect participants' confidence in commenting on effects on student learning. Also, the numeric data from the web based survey suggest that although the above effects were observed many considered them only mildly positive.

2. Barriers/impediments to change

Because an important step in achieving effective classroom change is carrying out the innovation, it was important when evaluating the NT workshop to explore how well the participants were able to implement the innovations and the factors that made implementing NT-related innovations difficult for workshop participants. This section describes two kinds of impediments that workshop participants encountered: those given as reasons why they had not yet tried specific NT-type innovations that they said they wanted to try (both pieces of information are from the follow-up survey, not the end-of-

workshop survey), and those complicating their efforts to execute innovations once underway.

The web and e-mail follow-up surveys featured a number of questions related to implementation difficulties. To use data from both surveys to answer this research question, the responses to the open-ended e-mail survey questions were coded to compare with both the forced-choice and open-ended items on the web survey.

Number of Workshop Participants with Implementation Difficulties

To provide an overview of the prevalence of implementation problems, we determined the proportion of faculty who made some sort of change to their teaching who also reported having any sort of difficulty. These figures were based on yes/no responses to the web survey questions that asked, "Did you encounter any difficulties in implementing these teaching/learning strategies?" To include e-mail survey data, responses associated with the e-mail question, "How did the implementation of this change or these changes go?," were coded based on evidence of implementation difficulty. As shown in Table 12, below, a little less than half (43%) of the survey respondents indicated some sort of difficulty with implementation.

Table 12 .

Workshop Participants' Difficulty with Implementation

Source of Data	Yes, Encountered Difficulties	No, Did not Encounter Difficulties	Total	Pct. with Difficulty
web survey	31	36	67	46%
e-mail survey	18	29	47	38%
Total	**49**	**65**	**114**	**43%**

Kinds of Impediments to Changing Teaching Practices

In this section we deal with two types of impediments to change: impediments that were actually experienced by participants when they made NT-type changes and reasons given by participants for why they had not yet made certain changes that, on the follow-up survey, they indicated they had interest in trying. On both surveys we elicited information about difficulties faced by workshop participants when they actually implemented NT-type innovations. Only the web survey asked specifically about the other type of impediment, although a few e-mail respondents addressed this question in their open-ended responses.

First, we will discuss the difficulties related to actual implementation of innovations, then we will examine obstacles mentioned by workshop participants as reasons why they had not yet attempted specific changes that they were interested in making.

a. Difficulties with implementing NT-related innovations

Workshop participants who reported changing their teaching practices as a result of the workshop experienced various difficulties that fell into four different categories:

- lack of student receptivity and cooperation
- lack of time for planning and execution
- logistical limitations and complications
- dept./colleagues' indifference and resistance

1) Lack of student receptivity and cooperation

The most common kind of impediment encountered by workshop participants who were changing their teaching was finding ways for all students to participate. First, faculty framed their reasons for why some students did not get involved in classroom and lab activities in terms of their attitudes. In some cases, workshop participants felt students were too passive or timid to take part in active-learning activities, although some students eventually felt comfortable enough to participate.

> Students are not used to such a format and many feel insecure not having a specific procedure to follow and are trying to guess what answer the instructor wants rather than spending time to think what answer should logically follow.
>
> The students were shy about the ConcepTests and did not participate very well.
>
> For the first few attempts at groupwork in class, students were reserved; however, they quickly overcame their apprehension.

Some faculty reported that some students were more obvious and outspoken in their resistance to these changes.

> It is not a "given" that students will actually sit and work on a problem assigned during class, group or not. Some refuse and sit, so motivation is one issue. Another is finding effective ways to convince students that reading and addressing challenge focus problems prior to coming to a class for discussion is imperative.
>
> With some classes, it seemed like they just did not want to participate . . . especially when it seemed if it required them to calculate something (a problem that required them to get their calculator and pencil out and write something down!)
>
> My senior-level students seem to hate anything that takes longer than lecture and telling them what to expect.

Second, some faculty associated students' lack of involvement with their intellectual and social skills. Although some workshop participants suggested that whether the students were "bright" or "slow" influenced how well NT-related innovations worked, there was no clear pattern to suggest that these new teaching approaches necessarily worked better with "smarter" students than with "weaker" students, or vice versa.

> One "slow" or unprepared student can hold up the group and not enough can be accomplished within the lab period.
>
> It worked better with brighter students.
>
> Many students hate to think! The sharp ones like the challenge; the challenged students feel overwhelmed.
>
> I did not have enough strong students to have one of them in every group, and consequently many groups were clueless when I did not specifically lecture about a concept.
>
> In a cooperative learning activity, one group member felt he needed to submit a report of his own as a supplement to the group report. He could have discussed issues with other members of his group a little more.
>
> Some students simply did not, and do not, work well in groups. Those students worked singly on homeworks, with a resultant lower average homework grade.
>
> I found that some students (usually good students) would rather hear the facts and read the book (like I was as a student).
>
> I don't think there was any change in the academically stronger students' performance, although I have seen students who really resented having to work with a weaker student. The students who seem to thrive in the group-learning situations are the weaker students who are highly motivated and like talking problems over with someone else. Then, there are those weak students who are not motivated and resent all attempts to get them more actively involved in learning. One such student wrote in his notebook, "Stop trying to make me learn!"
>
> Student response was mixed. A minority (the brightest students) loved the labs, while the majority just tolerated them. A few (not poor students, mind you) hated inquiry-based/discovery labs.
>
> Some students really like [active-learning approaches], while others, often better students, seem to feel that they do not need to do this type of work because they already "know" the material. However, they frequently find out that they don't, and can't explain it to others! Consequently, the less able students often do better in group work because they take the group work seriously.

Finally, faculty characterized their difficulties as occurring with particular groups of students. For example, grade level mattered when implementing NT-related innovations in more than one class, with upper-division students typically being more resistant.

> In a freshman course, this implementation worked well. In an upper-level class, students were not willing to engage themselves.
>
> I have conducted a Summer Bridge program for incoming freshman with cooperative learning using worksheets I developed. It has been very effective.
>
> I think that the pre-elementary teaching physical science classes were more receptive [than my senior-level students].
>
> I think that students began to realize that they needed to think about what they were learning. In a sense, that's why the upper-level students were not engaged. They seem to want the information and then digest it later.

2) Lack of time for planning and execution

It was no surprise that, second to getting students to participate, insufficient time was a significant impediment to implementing NT-related innovations. First, some workshop participants explained that they lacked time for adequately planning and readying classroom and lab activities.

> [I had difficulty with] coming up with the ideas and the time to make a coherent lesson using active learning takes time, time that I usually do not have.
>
> [I had difficulty with] time and effort to set up, oversee, and grade.
>
> I had difficulty writing my own ConcepTest questions. I was pushed for time with too many preps.
>
> I had planned to use lectureless learning in all my recitation classes, but I ran out of time to write up the worksheets and then to train the TAs.

Some faculty also lacked time in class for carrying out the activities.

> [I had difficulty with] finding time in class for in-class problem solving.
>
> It is more difficult to keep on schedule.
>
> My principal difficulty during class was not having as much time as I would have liked to talk with each working group about what they had done and to answer their questions.
>
> Guided-inquiry experiments require more time and effort than "cookbook" labs for students and faculty.

3) Logistical limitations and complications

Workshop participants reported they encountered a number of logistical and technical difficulties in the course of implementation. One such complication was limitations of classroom space.

> Some methods worked, while others don't (depends on lots of factors). For example: some of our classrooms are not amenable/suitable for group work.
>
> The layout of our large lecture hall makes groupwork difficult, but I tried to use strategies discussed in the NT workshop like simply pairing students sometimes instead of trying groups of 3-4 students. When teaching in a smaller classroom with mobile desks, the group interactions were much more comfortable and, most likely, more effective.

Another problem some faculty encountered during implementation of ConcepTests was formulating and refining questions. For some, it was difficult to craft questions that did not overwhelm students; others found it difficult to create CTs for a particular kind of chemistry.

> It has been a challenge for me to formulate questions.
>
> [Implementation of an NT-related innovation in my classroom went] quite well, but I need to refine the way I post the questions.
>
> [Implementation of an NT-related innovation in my classroom went] pretty well, but I need to make refinements and implement actual ConcepTests, etc.
>
> Sometimes it has gone well. Other times, I've had difficulty getting the students to discuss the questions. Perhaps the questions I've used were not at the appropriate level of difficulty.
>
> I find it difficult to come up with effective concept tests for analytical or environmental chemistry.
>
> I am having some difficulty developing appropriate concept tests for instrumental. I teach instrumental at a very practical, application-oriented level. But I want students to analyze choices and think about what we are covering.

Finally, faculty ran into problems with the "technology" used to implement the innovation. Used in a broader sense, "technology" includes ConcepTest voting cards as well as typical forms of technology.

> The anonymous way of having them vote was a pain—I'd forget the cards—so I just had them raise their hands.
>
> The possibilities for technical difficulties have increased as we rely more on computers.
>
> I tried to implement ConcepTest without using the ABCD cards, allowing student to raise their hands instead. As a result, some students did not respond. Next year, I will have the cards and ask them to vote all at once.

4) Lack of collegial support

Some workshop participants indicated that resistance and lack of interest from others in their department (including teaching assistants) sometimes made implementation more difficult.

> I had no long-term continuation [with an NT-related innovation]. I think my duties as division chairman and as a very active faculty sponsor make it difficult for me to sustain the effort, especially when my two colleagues are not stimulating me, nor is anyone else encouraging me—other than this survey itself.

> Some of the TAs were either resistant or did not clearly understand the expectations, particularly in the changes made in directing discussion sections. Others were excellent.

> Some recitation TAs used them, some tried and abandoned the ConcepTests, and some didn't try them. I visit recitations but not often enough to observe the extent of their use and really work with TAs on it.

b. Obstacles to initiating innovations of interest

On the web-based survey, we asked participants to indicate which of the 17 NT-type innovations they were interested in trying. For those who picked one or more innovations, we asked them to explain why they had not yet made these changes. Analysis of their reasons for not making these desired changes indicated that these types of impediments to change were similar to those associated with actual implementation (namely, lack of time for planning, lack of student engagement, logistical limitations and complication, and lack of collegial support). However, these types of obstacles took slightly different forms. For example, a number of workshop participants who had not yet attempted particular NT-related innovations suggested lack of time was a problem during planning rather than during implementation. As one workshop participant who was interested in trying both lectureless chemistry and thematic teaching explained,

> To redirect your entire philosophy for a course takes a full summer of uninterrupted time, which is not possible when doing student research. I think a sabbatical in this area would be very helpful and satisfying.

With regard to student resistance, a number of workshop participants said they expected problems with getting students involved.

> Inquiry-based labs, I believe, are not appropriate for our students (and students at most universities)...[Regarding challenge problems,] (1) I have students with extremely different abilities in the same class making it difficult to choose problems where everyone would be challenged and can contribute. (2) It's difficult to spend time on challenge problems when many students cannot do the basic problems. (3) With many commuter students, it's hard to get groups of students together outside of class time.

When describing logistical limitations and complications, some workshop participants said they were waiting for better materials.

> [Regarding ChemLinks modules] I have seen incomplete modules on the web. It would be nice to have the whole module curriculum for general chemistry [courses.] The ideas that I see presented there seem very innovative but incomplete. There is no sense reinventing the wheel and trying to come up with my own module on global warming, for example.
>
> [One problem is a] lack of detailed materials and examples of how these innovations were implemented.

And, in the case of collegial resistance or indifference, a few workshop participants explained that, as untenured faculty, they were uncomfortable with the risks associated with trying a new teaching method, such as negative course evaluations.

> I like the idea of thematic teaching, but as an untenured assistant professor, I am not yet willing to take the risk involved with such a different approach than what is currently "accepted" in our department.
>
> [Regarding modules, I face] resistance from faculty peers teaching the same course at the same time, highly negative responses from students who have used this method, and importance of student evaluations for tenure decision.

In addition to these four kinds of obstacles, workshop participants also mentioned other issues that influenced whether they attempted an innovation that interested them.

1) Lack of opportunity to attempt changes

A few workshop participants explained that they had not yet attempted an innovation because the opportunity to do so was not yet available. In one case, not much time had passed between the workshop and the follow-up survey, so a workshop participant was still awaiting resource materials he had needed to plan particular projects. And, another participant had not yet had an opportunity to teach the lecture course in which he planned to make changes.

2) Lack of understanding about the actual pedagogical practice or how to evaluate its effects.

Several workshop participants said they still did not know enough about implementing the NT-related innovation they wanted to try.

> [With regard to lectureless chemistry,] I lack knowledge in building such a course.
>
> I guess I lack time to learn about and feel comfortable implementing and using [such] approaches [as challenge problems, conceptests, thematic teaching, and lectureless chemistry]. I would like to know the learning outcomes associated with using these techniques.

> I have never seen [calibrated peer review] done so I am a little timid about trying it with large classes.
>
> We are currently working on developing Inquiry-based Labs into the curriculum. I personally need to take more time to determine exactly what I would like to have assessed and how best to go about doing the assessment.

3) Inertia

Two workshop participants reported that they lacked the will to break old habits and make changes.

4) Lack of start-up resources

In addition to time, several workshop participants were without resources needed to set up the pedagogical innovations they had planned.

> [One problem is] not enough money to pay TAs to help with active learning classrooms.
>
> [One problem is] lack of lab assistance. Need support in providing resources for students.

Summary

In summary, it appears that, for those who actually implemented an NT-related innovation, the most common difficulties they encountered were getting students' participation and not having enough time to implement the innovation as well as they wanted. The biggest obstacle to pursuing interesting innovations was a lack of time.

3. Collaborative efforts to implement innovations

The follow-up surveys included a number of items that asked whether NT workshop participants made changes to their teaching in collaboration with others. One hundred and two of the 146 follow-up survey respondents indicated whether they had collaborated with others inside or outside their department when implementing an NT-related innovation. Of these 95, 51 (52%) indicated that they had collaborated with others.

As indicated in Table 13, below, these 51 workshop participants implemented NT-related innovations with different categories of colleagues (e.g., those who were or were not attendees of the NT workshop). *[Note: the total number of collaborations (74) exceeds the number of collaborating workshop participants (51) because some faculty engaged in collaboration with more than one category of colleague.]*

Table 13.

Types of Collaboration, by Particular Categories of Colleagues

With whom did participants collaborate?	***n***
Departmental colleagues who attended NT workshop	32
Departmental colleagues who did not attend workshop	24
Colleagues from another institution who attended NT workshop	6
Colleagues from another institution who did not attend workshop	5
Not enough information provided about collaborators	7
Total	**74**

The fact that 29 of the instances of collaboration were with colleagues who had not attended the NT workshop suggests that the workshop may be having an impact on a larger group of faculty than just those that attend the workshops.

4. Other feedback on strengths and weaknesses of the workshops

On both the web and the e-mail surveys we asked participants to provide any additional feedback on the workshops. Below is a summary of the various issues that were raised by participants with regard to the strengths and weaknesses of the workshops:

- the workshop was very helpful and should be repeated;
- more data about effects of innovations is needed;
- planners might want to consider differences in institutional types in discussing implementation;
- time dedicated to talking with others was important, and even more may be desirable;
- more follow-up contacts and events with workshop participants would be helpful; consider providing ways for participants to remain involved and informed;
- perhaps too much time was spent "preaching to the converted"—consider moving into implementation activities quicker;
- future workshops might be aimed at different levels of experience with active learning; and
- offering various innovations increased likelihood of finding something appealing and feasible.

A more detailed report of participants' feedback will be provided to the NT Workshop planners.

III. Conclusions

Here we present key conclusions based on the data presented above.

A. Outcomes

1. Workshops Were an Effective Strategy for Disseminating Innovations

Data from the end-of-workshop survey about the potential impact of the workshops and the follow-up survey regarding the actual impact of the workshops indicate that, overall, the workshops were an effective strategy for disseminating the NT-type innovations. The strongest piece of data to illustrate this point is that most of the follow-up survey respondents (78%) indicated that they had made specific changes to their classroom practice as a result of the NT workshops. Further, those who did not report making changes were most likely not to have done so due to a lack of opportunity to implement changes that interested them since the workshop or the fact that, prior to the workshop, they were already using many of the NT-type innovations.

It is interesting to note that the patterns of planned change, as reported at the end of the workshops, are similar to those for actual change, as reported on the follow-up survey 6 months to 2 years after workshop participation. Here we discuss these similarities. Note: the population that received and responded to the end-of-workshop survey is not the same exact population that received and responded to the follow-up survey for two reasons: (1) the end-of-workshop survey was not administered to all workshops for which we conducted a follow-up survey, and (2) not all follow-up survey respondents that attended workshops at which the end-of-workshop survey was administered responded to the end-survey. Thus, there is a limit to the inferences that can be drawn from the following points.

On the end-of-workshop survey, 88% of respondents (159/181) indicated that they planned to make changes to their classroom practice as a result of the workshop. On the follow-up survey, 78% of the respondents (114/146) indicated that they had, in fact, made changes to their classroom practice as a result of the workshop. Although the figure on the follow-up survey is slightly lower, a number of the people who had not already made changes indicated on the follow-up survey that they were interested in making specific changes in the future.

The patterns for the percentage of respondents indicating on the end-survey that they were planning to try particular innovations was similar to those of the follow-up survey respondents' indications of which innovations they had actually tried. For example, with

regard to the four innovations that appeared most often on workshop agendas[11], ConcepTests, Inquiry-based Labs, Challenge Problems, and UW GenChemPages, the response patterns from both sets of surveys were quite similar. Most importantly, the first three of these were cited by a higher proportion of both sets of respondents than other specific innovations and the proportions were in the same order, with ConcepTests being most commonly cited. Additionally, the figures for the end-survey and the follow-up are even more similar if one considers the number of participants who indicated on the follow-up survey that they were interested in trying these innovations in the future and adds this to the number who actually made such changes. Table 14 (below), presents these data.

Table 14.
Data on Planned and Actual Changes to Teaching Practice

Innovation Type	Number of Respondents to End-svy Planning to Try	Pct. of End-svy respondents planning to try (N=181)	Number of Respondents to Follow-up-svy Actually Adapting/Adopting	Pct. of Follow-up svy respondents actually trying (N=146)	Pct. of Follow-up svy Respondents Wanting to try (N=146)
ConcepTests	116	64%	76	52%	3%
Inquiry-based Labs	62	34%	36	25%	10%
Challenge Problems	36	20%	28	19%	8%
UW GenChem Pages	2	1%	2	1%	3%

Data on actual classroom change consistent with emphasis on incremental change
It is interesting to note that at the end of the workshop and 6 months to two years after the workshop, of all of the NT-type innovations, participants were most likely to plan to or have actually used ConcepTests. We believe that this is due to the fact that ConcepTests are relatively easy to implement and to plug into an existing curriculum. By comparison, inquiry-based labs require much more effort and attention to logistical issues, and participants were less likely to have tried this innovation. This observation is consistent with the NT philosophy which emphasizes making smaller, incremental changes as part of a gradual shift to a more learner-centered approach to teaching.

[11] For analytical purposes, "innovations that appeared most often on workshop agendas" is being defined as those pedagogical innovations that have a fairly specific definition and constitute a single technique or strategy. Thus, this phrase does not refer to groups of innovations, such as "groupwork in lecture/discussion" and "cooperative learning.."

Some participants made changes in collaboration with others, including non-attendees of the workshops

Of the 95 respondents to the follow-up survey who answered questions about collaboration, 51 (62%) indicated that they had collaborated with others on implementing NT-type innovations. The fact that 29 of the reported instances of collaboration were with colleagues who had not attended the NT workshop suggests that the workshops may be affecting a greater number of faculty than just those who attend the workshops.

2. Workshops Benefited Faculty in Many Other Important Ways

The data show that virtually all (92%) of the respondents to follow-up survey reported some benefit from attending the workshops. The workshop benefited participants in multiple ways, beyond helping them make changes to their classroom practice, including gaining teaching insights and changing teaching philosophy, extended networks of faculty who are interested in teaching and learning, and increased enthusiasm for use of active-learning methods.

3. Effects on Students Seem Positive, More Data are Necessary

As shown in this report, respondents to the follow-up survey were largely positive about the effects of the NT-type innovations on their students. Faculty reported the following effects on students, largely based on anecdotal evidence: (1) increased engagement in learning activities, (2) increased student satisfaction with course experiences, and (3) increased student learning. However, a number of workshop participants indicated that, with regard to the NT-type changes they made to their teaching as a result of the workshop, they had problems with lack of student receptivity and cooperation and that the innovations seemed to have different effects on various types of students.

Our analysis showed that faculty were somewhat uncertain about the effects of the innovations on their students, because they lacked systematic measurements of this. Faculty expressed concern about the lack of these data, particularly with regard to effects on student learning. In addition, when the respondents were asked what types of innovations they would like to try, but had not yet tried, the most common response was "new approaches to evaluation and assessment." The evaluators believe that data on the effects of students could greatly enhance the evaluation of the NT workshops. Further, these data would benefit the faculty adapters of NT-type innovations as they would help them engage in change in a more systematic way, giving them more confidence in their decisions about classroom practice.

B. Workshops Served Two Purposes: Increasing the Number of Faculty Involved in Active Learning and Helping Other Faculty to Improve Existing Use of Active Learning Strategies

In general, we have observed that when faculty discuss efforts to disseminate teaching and learning innovations, the focus is on getting those who have not tried innovative strategies to try them. We found that the NT workshops served this purpose, but probably to a greater extent, they served the purpose of helping those who were already experienced with active learning to improve their use of these types of strategies and to try additional strategies. [Note that most of the NT-workshop attendees (69% of end-survey respondents) were experienced with active learning prior to the workshop.]

Throughout the data it was apparent that those workshop attendees who fell into the second category above (those who were already experienced with active learning) found the workshop quite valuable. The data suggested that classroom practices other than lecture required fine-tuning, as both the students and some of the faculty were continuing to adjust to this type of teaching and learning environment. Therefore, faculty found a need to work with other experienced faculty to hone their practice and learn about new techniques.

D. Key Factors Contributed to Workshop Success

The data indicate that there were several key aspects of the NT workshops contributed to their success as a strategy for dissemination of NT-type innovations. These factors were: (1) a hands-on approach, focusing on helping faculty "take-away" strategies for use in the classroom or laboratory; (2) a focus on incremental change, meaning that the workshop presented multiple strategies, most of which could be incorporated into existing courses, including a range of strategies from those that involved little restructuring/planning time (e.g., ConcepTests) to those that were systemic in nature (lectureless chemistry); (3) the informal workshop format that included ample time for discussion among participants and organizers; (4) the small size of the workshop group (average of 25 participants), and (5) the length (1.5 days) and timing (weekend) of the workshop.

Further, although we did not gather data that spoke directly to this issue, we believe that a strength of the workshop was that, for most of the workshops, participants were invited to attend and attendance was voluntary. Therefore, the workshop attendees were, for the most part, interested in active learning and excited to work with their colleagues to learn more about these strategies. This was an important factor in contributing to the fact that a benefit of workshop attendance for many participants was many an expanded network of colleagues who were interested in teaching and learning.

Of course, as with any effort, there are ways in which the workshops could be improved. Summaries of feedback from the end-of-workshop surveys on participants' suggestions for improvement have been given to the workshop organizers. The suggestion that

appeared most often on these surveys was to adjust the pace of the workshop so that the workshop stayed on track with regard to the scheduled agenda while still allowing enough time to discuss and work with each innovation.

E. Workshop Attendees May Need Continued Assistance

Several aspects of our analysis suggest that workshop attendees would benefit from some sort of follow-up activity initiated by the workshop organizers. First, a little fewer than half (43%) of the follow-up respondents indicated having some difficulty with implementation of the innovations. Second, many of the workshop attendees noted on the end-survey and the follow-up survey that an important benefit of the workshop was the opportunity to meet their colleagues from around the region who shared an interest in teaching excellence. Throughout these datasets were intimations that the workshop participants would appreciate opportunities to strengthen this network through continued interaction. There was a sense that the workshop helped participants develop a sense of being together in their efforts to create change in the classroom. Some faculty mentioned that, in their departments, they feel isolated, but that at the workshop they realized that they were part of a larger movement. It is reasonable to assume that the sense of isolation might return when the faculty members are back in their home departments. Finally, a few workshop participants specifically asked for "mentoring" or "follow-up" from the workshop organizers. The evaluators believe that the outcomes of the workshop would be enhanced if there was a follow-up component to the workshop. Two possible forms of follow-up to consider would be a phone call from the workshop organizers to discuss progress and offer assistance and a follow-up workshop.