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Effects of Using Single-Gender Group Exams in a Large, Introductory Geology Class

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Abstract

Studies have shown that women do better and feel more comfortable in science classes when cooperative learning techniques are used and when groups contain a critical mass of women. Group exams are one way to incorporate cooperative learning into a large-enrollment course. Trials of this method in a large introductory geology class indicate that making groups all-male and all-female helps many women and also some men to feel more comfortable with group work. Single-gender group exams thus provide multiple benefits for students in large classes.

Introduction

Large-enrollment courses tend to be difficult for teachers and students alike. Teachers struggle with the management of so many students and often feel that they cannot run the class the way they would in a small-enrollment course. Many students feel lost in the crowd, disconnected from the teacher, and more like audience members in a theater than participants in a classroom. To counteract some of these problems, many instructors have begun incorporating cooperative learning activities into their large classes (e.g., Macdonald and Korinek, 1995; Ebert-May et al., 1997; Wyckoff, 2001). These activities can take many forms, from think-pair-share exercises to group projects. Students were reported by Bykerk-Kauffman (1995) to be more enthusiastic about group exams than any of the other cooperative activities she tried.

Another issue that teachers may struggle with is how to make science a more inviting subject for women, both in terms of improving science literacy and for recruiting majors into fields in which women are traditionally underrepresented (Rosser, 1995). Studies have shown that one of the most effective ways to increase women's comfort level and performance in science is to use cooperative learning methods in the classroom and laboratory (Rosser, 1992). The make-up of groups is critical in creating a positive learning experience for women, however (Light, 1990). Although it is commonly recommended that teachers choose groups to maximize the gender and racial diversity within each group (e.g., Slavin, 1990), this can be a poor strategy for women and minorities in fields like science that are nontraditional career choices (Rosser, 1997). Women may feel isolated or excluded if they are the only female in a group, at least in part because men have a tendency to interrupt women and dominate classroom discussion (Hall and Sandler, 1982). A "critical mass" of women in each group is important (Etzkowitz et. al, 1994). Taking this idea even farther, "the female-only environment gives women an equal chance," and "cooperative techniques...have proved particularly successful in all-female environments" (Rosser, 1997, p. 56). Most colleges and classrooms are coeducational; however, so special steps have to be taken to create comfortable "microclimates" for women in science courses.

As a teacher handling large, introductory courses, I wondered if giving group exams using single-gender groups would be the optimal way to both encourage active learning and level the playing field for women in the coeducational science classroom. During the Spring 2001 semester at Winona State University in Minnesota, I experimented with this method in the lecture portion of a physical geology course entitled Dynamic Earth. The course had 130 people enrolled, of whom 81 were women, and 49 were men. I kept track of the scores of individuals and their groups and administered a detailed student evaluation of the group exam format at the end of the semester. In these data, I found differences between the performance of men and women, as well as individuals and groups. Men and women also showed differences in their degree of comfort with this method, although most students were very positive about it. While not giving a definitive answer about whether single- or mixed-gender groups are superior, this study provides information that may help other teachers decide whether they

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should start using single-gender groups for cooperative learning exercises in large-enrollment science courses.

Group Exam Format

The group exam format I used is similar to that described by Bykerk-Kauffman (1995) and Mouton and Blake (1975). To eliminate confusion during the test, students sat with pre-assigned, single-gender groups of 4-5 students in pre-assigned seats on exam days. I first administered a 25-question, multiple-choice exam to individuals with no talking allowed. Students were asked to stay seated and quiet and hold onto their score sheets until everyone was done. Once the individual score sheets were taken up, each group was given a new score sheet, and students took the same exam again with their group. Consensus was required on the answer to each question because only one score sheet could be turned in per group. With only 25 questions on each exam (half the number I had previously used when doing only individual exams), I found it easy to finish the whole exam process in one 50-minute class period. I also felt comfortable making the exam questions more challenging and thought provoking because students would have an opportunity to discuss the questions with others.

Because this testing procedure is relatively complex compared to a typical exam, at the end of the first week of class, I gave students a 10-question pre-test for no credit. They took the test in exactly the same way as they would the real exams. I think a "practice run" like this is essential to get students comfortable with the group exam format and allow them to identify their assigned seats and group members before the first exam.

I computed students' exam grades, referred to below as their combined scores, as a weighted average of the two scores: 75% individual and 25% group. If students had an excused absence on an exam day, they took the test only as individuals, and this score counted for 100% of their grade. For the final exam, students took only the half of the test that covered new material in the group exam format. They took the comprehensive review portion only as individuals, so 12.5% of the total grade came from the group score. Keeping track of grades became somewhat complex, but I felt it was important that the final exam reflect individual performance as much as possible without sacrificing the educational value of the group exam format.

If a group disagreed with me on the answer to one or more exam questions, it had one week after the graded exams were returned to file a petition for reconsideration. Each petition had to include the group members' names, the question number(s) being petitioned, a persuasive argument why their answer was correct and mine was not (hopefully this included a reference to pages in the text that supported their argument), and the individual and group score sheets. Only groups who submitted a petition that I approved received credit for the question; others had no change in their score. Many students appreciated the opportunity to petition a question because they felt it made the testing procedure fairer (Appendix 1). I also found the petitioning process valuable, although it made keeping track of grades even more complex. It enabled me to see where students had conceptual difficulty with the material and how they misinterpreted the wording of my multiple-choice questions. This information allowed me

to improve my test-writing abilities in an attempt to create questions that were "petition-proof."

In assigning students to groups for the first time, I chose to keep students in the same lab section together so that they would be working with people they saw regularly in a smaller class setting. Not knowing the students personally, I simply grouped them alphabetically in 32 single-gender groups of 4-5 students. After the second exam, I shuffled students around into a second set of 30 groups. This time, I attempted to place in each group at least one student who averaged a B+ or better on the previous exams; I also tried to distribute the academically weaker students fairly evenly throughout the groups. The composition of the lab sections required me to create a few male groups with people from more than one section. For the final exam, I polled students on whether they preferred to work in the first or second set of groups. The vote was fairly close, but the majority chose to work with the first set again.

An important issue that I had to resolve with this exam format was how to handle students with learning disabilities and/or special exam-taking needs. Such needs may include a low-distraction environment, having extra time, and taking exams orally or with computer assistance. The solution I found was to allow such students to take the individual portion of the exam in the campus testing facility a day or two before the regular exam period. They then came to class, sat quietly through the individual portion of the exam, and participated in the group portion along with everyone else. In exchange for testing accommodation, I found that these students readily agree not to discuss the exam questions with other class members ahead of time.

Testing Outcomes

To analyze student performance on the exams in my class, I calculated the mean and standard deviation of scores for male and female individuals and groups (Figure 1). I also performed a two-sample t-test to test the hypotheses that groups scored better than individuals did and that males scored better than females (Table 1). To learn more about group dynamics, I compared the maximum individual score within each group to that group's score (Figure 2).

Table 1. Results of two-sample t-tests on exam scores

Exam Number	*Groups > Individuals (all)*		*Males > Females (individuals)*		*Males > Females (groups)*	
	t	*p*	*t*	*p*	*t*	*p*
Exam 1	9.70	<0.0005	1.09	<0.15	0.59	>0.25
Exam 2	9.86	<0.0005	2.06	<0.025	0.77	<0.25
Exam 3	8.67	<0.0005	3.02	<0.0025	1.45	<0.10
Exam 4	11.74	<0.0005	2.60	<0.01	0.50	>0.25
Final Exam	7.80	<0.0005	3.85	<0.0005	1.47	<0.10

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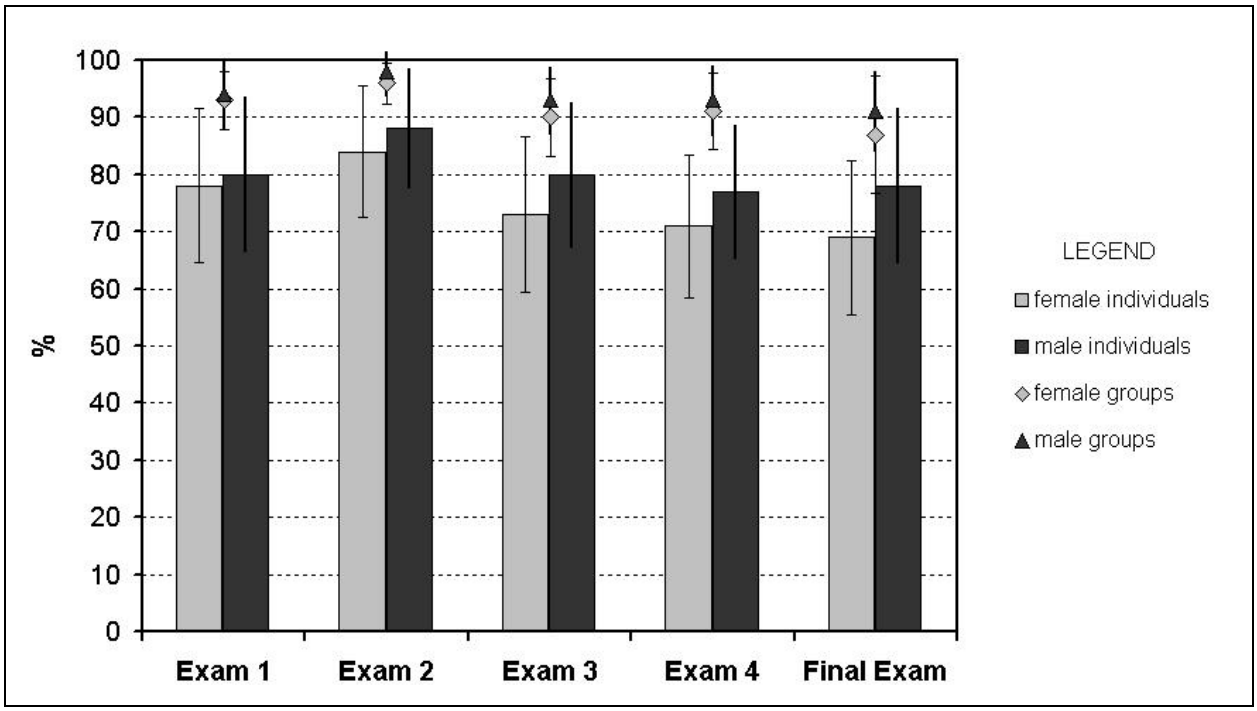
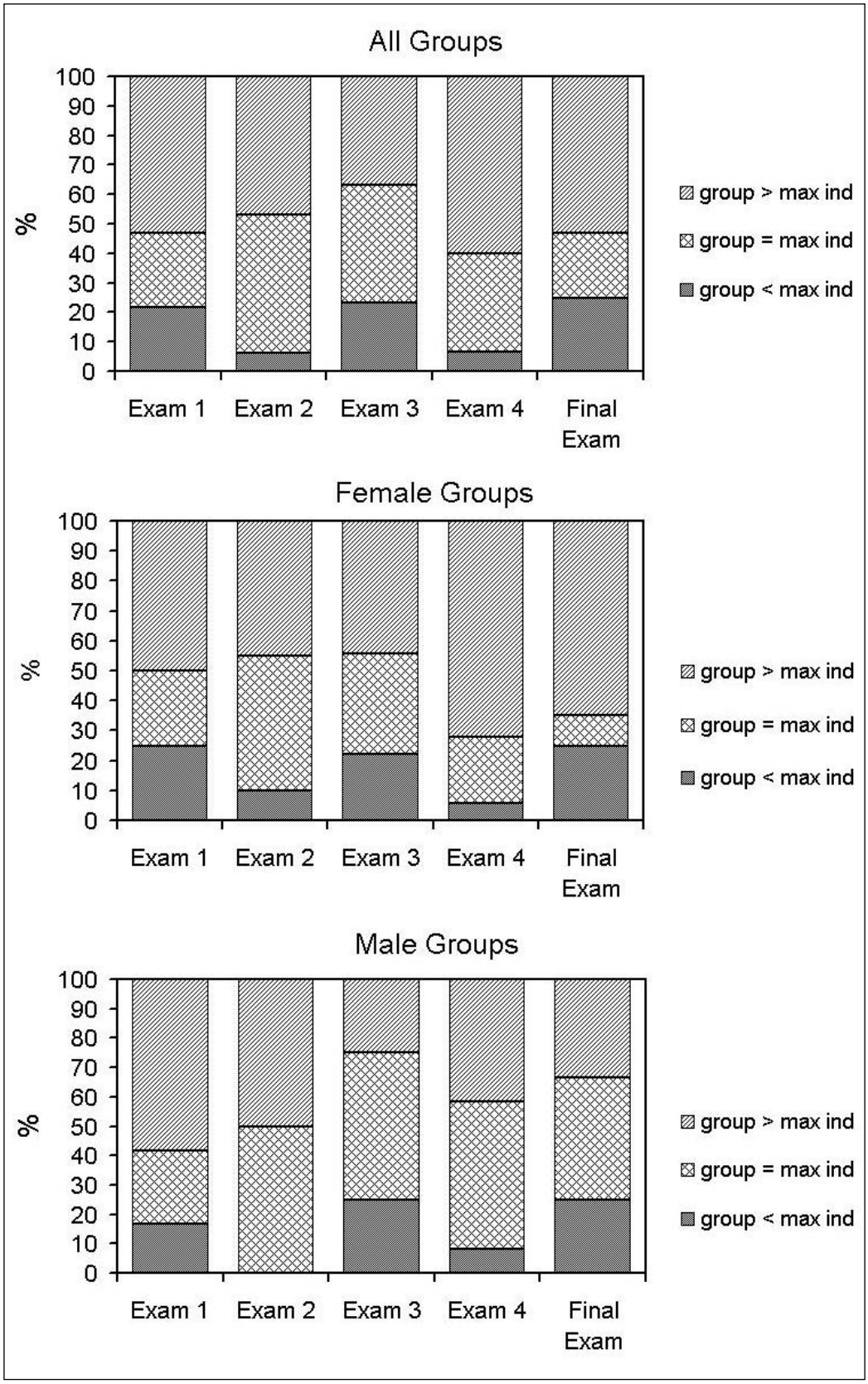


Figure 1. Mean scores for male and female individuals and groups on all five exams. Vertical lines show ± one standard deviation. For the final exam, only results from the half that covered new material and was tested using a group exam are reported here. Men's individual scores were significantly higher than women's on all but the first exam, but male and female group scores were not significantly different (see Table 1 for the statistics).

[Figure 2 on next page]

Figure 2. Percentage of groups (female, male, and both sexes together) earning a score greater than, equal to, or less than the maximum individual score within the group (labeled "max ind") on each of the five exams. Again, only the scores from the new material on the final exam are reported here. When groups earn better scores than the highest scoring individual within the group, cooperative learning appears to be successful; when the opposite is true about the scores, groups are not functioning as effectively. When the group and maximum individual scores are equal, groups may be relying primarily on their best-prepared member to provide the answers instead of pooling everyone's knowledge together.



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Individual Versus Group Scores

On all five exams, the groups did significantly better on average than individuals ($p < 0.0005$; Table 1 and Figure 1). The average group score was 12-19 points higher than the average individual score, so the general effect of the group exam on student grades was positive. By weighting the group score at 25%, student's combined scores were only raised an average of 4 points above their individual scores. The maximum increase was 14 points, but this situation only occurred when a student did miserably as an individual yet happened to be in a group that earned a very high grade. Although some teachers may be uncomfortable with this situation, I find it more important that these students actually did get exposed to the correct answers to most of the questions during group discussion. This is more than can be said of many individual exams. The usually small increase in scores seemed to be enough to make students feel good about taking group tests, but I did not find it sufficient to change grade distributions or to keep very weak students from earning poor marks.

One line of evidence showing that cooperative learning was occurring during group work is that in 37-60% of the groups on each exam, the group score was better than the maximum individual score within the group (Figure 2). Students, at least in these groups, were pooling their knowledge and not simply using the answers of the one person they considered the "smartest." These high percentages support the idea that the group exam is an effective cooperative learning method.

On the other hand, 6-25% of the groups earned a lower score than the highest scoring individual within the group (Figure 2). In all of these cases, the difference was only 1-2 more questions wrong on the group exam than the best individual test. The people who earned these lower group scores may have been ineffective at convincing their group members that they knew the right answers, or perhaps they were in groups with very persuasive but less knowledgeable members. Only four people in the class allowed this to happen to them on more than one exam.

In an interesting illustration of group dynamics, the percentage of groups that earned a lower score than their maximum individual score dropped dramatically the second time students worked in a particular set of groups. For Exams 1 and 3, the value was 22-23%; but for Exams 2 and 4, it was 6-7% (Figure 2). After one exam together, either the group members realized who they needed to listen to, or the high-scoring students learned how to make themselves be heard. Surprisingly, on the final exam when students returned to their original set of groups, this percentage reached a high of 25%. The implication is that if a particular group does not work together for several weeks, they must effectively start over again in their group dynamics. The teacher's goals for the cooperative learning experience are thus relevant in deciding whether it is better to have students work in the same groups throughout the term or to mix them up periodically. Because something is learned in both situations, I believe that the choice is not critical to the success of this cooperative learning method.

Men's Versus Women's Scores

On all the exams in this particular class,

men scored higher on average than women: 3-9 points higher individually and 1-4 points higher in groups (Figure 1). Although at least one man and one woman always got a combined score of 97 or 100%, the minimum combined score for women was 2-17 points lower than for men. Performance of two-sample t-tests shows that male scores were significantly better than female scores ($p < 0.05$) only on the individual portion of Exams 2, 3, and 4 and the final, however (Table 1). In an effort to determine why an individual score difference occurred, I put two questions on the end-of-term evaluation that probed students' early interest in geology-related subjects and the confidence they had in their ability to do well in science (questions 9 and 10, Appendix 1). The results indicate that more of the men brought strong interest and high confidence levels to the class. Without further information, I cannot say whether this background accounts for the difference in individual performance or if differences in study habits also played an important role.

Although women's individual scores were lower on most exams, their groups appeared to function more effectively than men's groups. In other words, women's groups seemed to pool their knowledge better and work more cooperatively. Average female group scores were 13-21 points higher than the average female individual scores, whereas the average male group scores were only 10-16 points higher than average male individual scores. As a result, women's group scores were not significantly different from men's on any of the exams (Table 1 and Figure 1). (Note that weighting the group score more heavily in the combined score would have helped to equalize men's and women's average test grades even further.) In addition, 44-72% of women's groups earned a higher score than their maximum individual score, an indication that cooperative learning was occurring; and this percentage showed marked increase on the last two exams (Figure 2). In contrast, 25-58% of men's groups achieved a higher score, but the percentage showed an overall decline during the term. As would be predicted from previous studies (Rosser, 1997), women appear to have come in with better cooperative skills and strengthened them during the semester. Men, on the other hand, seem to have had more difficulty working cooperatively. Their groups were more likely to earn the same score as the maximum individual score within the group (Figure 2), possibly indicating a group strategy in which the high-scoring individual(s) dictated the discussion.

If enjoyment and skill can be correlated, the results of the end-of-term evaluation support the idea that women worked together better than men (Appendix 1). While the vast majority of students liked the group exam format, women in the class enjoyed the group work more than men did. A greater number of women also reported that group discussion made the exams less intimidating than they would otherwise have been. While both sexes experienced some degree of frustration with group members who talked too much or too little, approximately 85% of men and women reported that all their group members participated on some level. Men reported a slightly higher incidence of dominant talkers and silent listeners. Perhaps most notably, only a handful of men and no women felt that the group exam format was so unfair, uncomfortable, or otherwise problematic that they would attempt to avoid it in future classes. I have observed that many students who prefer to work independently find cooperative learning

to be distasteful in principle and practice, so I think this result is an important indication of the success of the group exam method.

Also encouraging was the response that 95% of students felt that they studied as hard or harder for the group exams than they would have for a purely individual test (Appendix 1). Apparently this format did not encourage students to rely on others to pull their grade up. Although roughly half the class only studied for exams by themselves, women studied in groups somewhat more frequently than men did. Despite the fact that students knew their group assignments well in advance and had lab with group members, they did not seem particularly motivated to study with their testing groups.

Without being able to compare results for a series of exams with the same students in mixed-gender groups, it is impossible to say for certain if using single-gender groups significantly improved the group exam experience for students. On the end-of-term evaluation, most students (66% of women and 73% of men) reported that they felt equally comfortable in single-gender groups as they would have in mixed-gender groups. I think it is very significant, however, that 34% of women and 20% of men reported that they felt more comfortable in single-gender groups (Appendix 1). In contrast, none of the women and only 7% of men (3 students) said they felt less comfortable in single-gender groups. Using single-gender groups thus appears to do no harm and, in fact, to help many men and women feel more comfortable interacting in groups.

Conclusions

Given the more effective cooperation of women's groups and the greater degree of comfort many students feel in an all-female or all-male group, I think that there is good reason to use single-gender groups for at least some cooperative learning exercises in large-enrollment science classes. It takes no more time for a teacher to assign single-gender groups (actually less time than for highly diversified groups), and students do not seem to find them objectionable. With the weight of evidence that has been amassed for the different needs of women and minorities in science classes (Rosser, 1997), it is worth reconsidering the common recommendation to assign groups in a way that mirrors classroom diversity. In fields like science where many students are phobic of the subject matter, it can be important to provide some degree of comfort in the group work environment so that other problems do not get in the way of learning. The results of this study show that single-gender groups appear to provide that extra comfort for many men as well as women.

From these experiences with the group exam, I recommend it as an excellent way to incorporate cooperative learning into a large-enrollment course. Students seem to like the format because they recognize the positive effect it usually has on their grade. I like it because it reinforces the concepts covered on the test, motivates a high level of student participation in group work, and often leads to improvement over time in a group's ability to work together as a team. As a result, group exams are a real learning experience for students and not simply an assessment tool for the teacher. By using single-gender groups on these exams, even

greater benefits can be realized, particularly for women.

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Appendix 1

End-of-term evaluation of group exam format (95% response rate)

	% of women (n = 79)			% of men (n = 44)		
Statements	*strongly agree/ agree*	*neutral*	*disagree/ strongly disagree*	*strongly agree/ agree*	*neutral*	*disagree/ strongly disagree*
1. I like being able to take each exam in a group as well as individually.	94	5	1	82	4	14
2. Group exams are a positive learning experience for me because I get a chance to talk with my classmates about the course material.	91	8	1	79	14	7
3. I found the exams in this course less intimidating than they might otherwise have been because I knew I would get to take them in a group as well as individually.	76	21	3	61	25	14
4. I feel that the individual and group exam format is a fair way to help improve people's test scores.	97	3	0	84	7	9
5. Because of my experience with group exams in this class, I would not hesitate to sign up for another course in which this same type of exam format was used.	94	6	0	79	14	7
6. During the group exams, all the group members eventually participated in the discussion at some point.	86	6	8	84	5	11
7. During the group exams, I felt that one or two people tended to dominate the discussion and some people rarely contributed at all.	33	31	36	43	21	36

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8. I appreciate the opportunity to petition for reconsideration of any test question whose answer I disagree with.	95	5	0	82	14	4
9. Ever since I was a child, I have been interested in subjects like the outdoors, rocks, dinosaurs, and wildlife.	47	32	21	66	23	11
	very strong/ strong	*mediu m*	*weak/ very weak*	*very strong/ strong*	*mediu m*	*weak/ very weak*
10. In general, I would rate the confidence I have in my ability to do well in science as:	37	50	13	66	27	7
	more	*equally*	*less*	*more*	*equally*	*less*
11. I feel _____ comfortable taking the group exam in an all-male or all-female group compared to how I would feel in a mixed-gender group.	34	66	0	20	73	7
	harder	*about the same*	*not as hard*	*harder*	*about the same*	*not as hard*
12. Knowing the breakdown of my exam score is 75% individual and 25% group, I believe I studied _____ for the exams in this class compared to a class with only individual exams.	15	80	5	7	89	4
	. 4, 3	*2, 1*	*0*	*. 4, 3*	*2, 1*	*0*
13. Before _____ of the exams in this course, I studied with member(s) of my testing group.	1	18	81	11	18	71
14. Before _____ of the exams in this course, I studied with classmates who were not members of my testing group.	23	37	40	23	25	52

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Does Mid-Semester Feedback Make a Difference?

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Abstract

Informal mid-term feedback processes create opportunities for students and academics to have a dialogue about their progress and to make any necessary or reasonable mid-stream corrections. This article reports on an action research project designed to see what impact mid-semester feedback might have on the classroom experience. The underlying motive for the study was to generate institution-specific "proof" which might encourage other academic staff to conduct informal mid-semester informal feedback exercises with their students.

End-of-semester data shows that both students and lecturers found the exercise to be a positive experience. Students appreciated being to voice their problems and opinions at a time when mid-course corrections were possible. Lecturers felt there was an improvement in the lines of communication, resulting in a friendlier teaching and learning environment.

Background

With student enrolment of 3500, Lincoln University is New Zealand's smallest university. Lincoln enjoys international recognition for teaching, research, and service in its multi-disciplinary and applied educational programs. As part of its quality assurance processes, the university requires that all subjects be evaluated on a biennial basis and encourages all teaching staff members to conduct lecturer evaluations at least every three years. Though these processes are intended, in part, to be used for the purpose of improving instruction; they are actually summative feedback mechanisms. That is, they occur after the instruction has been completed and give no opportunity for follow up interaction between the students and lecturer. Any changes made as a result of student feedback must wait until the following year.

Academic staff members have often expressed a desire for an opportunity to respond to students' end-of-semester comments on their teaching. The timing and processes that the University currently follows does not permit this interaction.

Staff within the university's academic support unit, Teaching and Learning Services (TLS), have long encouraged lecturers to obtain mid-semester, formative feedback from their students. Informal, mid-term feedback processes allow students and teachers to have a dialogue about what is working and not working in the class and to make any necessary or reasonable mid-stream corrections. This exchange gives students an opportunity to be heard and for university staff to bring to their students' attention the difficulties involved in organising and delivering a university subject.

Problem Statement

Obtaining and responding to students' mid-semester, formative feedback is intuitively a good idea. However, academics were reluctant to take on an additional assessment task and TLS staff had no "proof" that this exercise would make a difference in the local teaching and learning climate.

Participants/Procedures

Our opportunity to explore the idea came when the head of an academic division's Education Development Committee came to talk with us about staff frustrations with the present evaluation systems. Their particular concern was that they cannot make any changes students might suggest until the next time the subject is offered.

TLS staff proposed a collaborative research project to determine the use and value of formative, mid-term feedback within the division. Despite our plea that TLS' position was one of encouraging, not mandating, the use of mid-semester feedback; some staff within the division expressed concern that this was actually an entry effort to make mid-semester feedback mandatory. As a result, only four members of the division agreed to participate and the study was redesigned to be of an exploratory nature.

The research questions were:

- In what form, if any, do teaching staff currently obtain mid-semester formative feedback from their students?

- How, if at all, is this mid-semester feedback used to engage students in a dialogue on how the subject may or may not be modified for the duration of the semester?
- How, if at all, does instituting a mid-semester feedback exercise alter subsequent delivery of a subject within the semester?
- How, if at all, does instituting a mid-semester feedback exercise make a difference in terms of student and lecturer satisfaction with the teaching/learning process?

(The researchers were not interested in proving one method of obtaining feedback was superior to others. Nor were they concerned with the actual content of the feedback obtained from students. The focus was solely on any qualitative differences that engaging in this type of exercise might make.)

The four participating lecturers agreed to:

- obtain informal feedback from students in the week prior to the mid-term break;
- in the week after mid-term break, engage students in a dialogue about their feedback and, where reasonable and agreeable to all parties involved, modify subsequent delivery;
- participate in an end-of-semester interview with TLS staff; and
- schedule a formal subject evaluation for obtaining end-of-semester student feedback.

TLS staff agreed to:

- assure that all participating academics are fully aware of the options available for obtaining informal feedback from students;
- manage the end-of-semester staff interview and student feedback process;
- collate and review all end-of-semester data; and
- report findings directly to the division's academic staff.

Results from the Students

Mid-semester and end-of-semester feedback was gathered from one third-year, one second-year and three first-year subjects representing the disciplines of communication, psychology, and recreation management. The lecturers, as agreed, conducted the mid-semester feedback exercise. End-of-semester ratings were gathered from 118 students by TLS. The normal procedures for processing subject evaluations were used, with the exception of additional questions pertinent to the study being added to the evaluation instrument. Those questions were:

1. What benefits were there in providing/receiving feedback at mid-semester?
2. In what ways did the lecturer respond to the feedback you (students) gave at mid-semester?
3. Were there things not addressed in the feedback from the lecturer?
4. Would you like to see other lecturers use mid-semester feedback? Why or why not?

The data gathered were subjected to both quantitative and qualitative analysis. For quantitative purposes, the questions were re-phrased into a format suitable for "yes/no/unsure" categorisation.

Student Responses to End-of-Semester Questions (N = 119)

	yes	no	No response	Unsure
Q1: Were there benefits in providing and receiving feedback at mid-semester?	84%	5%	8%	3%
Q2: Did the lecturer respond to the feedback you (students) gave at mid-semester?	74%	3%	20%	3%
Q3: Were there things not addressed in the feedback to the lecturer?	8%	47%	36%	8%
Q4: Would you like to see other lecturers use mid-semester feedback?	81%	8%	7%	4%

Question One –

Ninety-nine students (84%) responded that there were benefits gained from engaging in the mid-semester feedback exercise. Forty-nine students listed specific ways that the exercise benefited themselves as students. Sample comments:

- It gave us an opportunity to voice opinions earlier in the semester, so if there was something we were having trouble with it could be addressed.
- We had a chance to address any issues during the semester. We had a chance to be heard and, if needed, clear the air somewhat.
- Changes could be put into effect and benefit us, the current students.
- We could give our thoughts on how to make points clearer.
- [It gave] an opportunity to air grievances or clarify vague aspects during the class rather than later or afterwards.
- It was helpful to know that other students shared similar views or feelings.

Thirty-nine students listed specific benefits for the lecturer. Sample comments indicating benefits to the lecturer and/or the lecturer and students:

- The lecturer had an idea about the class situation – good.
- Lecturer knew what they needed to work on.
- Lecturer could change style of teaching in response to feedback.
- Lecturer knew what problems there were and could try and remedy them.
- The lecturer was offered a chance to improve their teaching methods, based on student feedback.
- Improved communication between students and lecturer.
- We could "iron out" a few things and make the class suit us and the lecturer better.
- Chance for the lecturer to address any problems the class may have had. Gives class the chance to say what they are enjoying and what the lecturer is doing well.

Five students gave examples of how the class delivery changed as a result of the exercise.

- Changes were made to teaching style, how the lectures were conducted.
- Changing teaching techniques before the exam.
- Lectures got better.
- The lectures changed slightly.
- Some things changed in lectures; according to our comments.

The nine students who saw no benefit from the exercise were distributed among four of the five papers (n=1, 4, 2, 2). The comments from the four

students who elaborated on their answers were:

- Not a lot, as I was quite happy with the paper and lecturing style at this time.
- Not much, I guess, but I still think the mid-semester evaluation is a good idea. It means students and teachers can sort out problems – I don't have any problems with the class.
- It doesn't need to be reviewed in classes. A waste of time because the lecturer just listed excuses.
- Only interesting, didn't effect [sic] the students.

The two students who were labelled as 'unsure' reported "I didn't know we got any feedback" or "I was away that day."

Question 2 –

The intent of the second question was to determine in what ways (if any) the lecturer altered the delivery of the course. Unfortunately, the item was worded in such a way that 52 students interpreted the question to mean "in what manner" did the lecturer respond to their feedback. (All noted that the lecturer talked about the results in class. Thirty-six said that the lecturer displayed a summary of the results.) Twenty-nine students did state that the lecturer implemented changes in response to their feedback. The types of changes mentioned included: the use of larger fonts for overhead transparencies, greater use of videos, earlier placement of lecture notes on the class web pages, better explanation of technical terms, and, in general, better lectures. Four students noted the positive way in which the lecturer received and responded to their mid-semester comments. Only two students reported there being no change in lecturer behaviour.

Question 3 –

Nine students (8% of the total) reported that there were some points of feedback that the lecturer did not address. These students either indicated ambiguously that "some things not addressed" or said that there was "not much discussion on the bad points."

Question 4 –

Ten students responded that they would not like to see other Lincoln lecturers using the mid-semester feedback; however, two of these indicated that their reason for this statement was that they were "usually happy" with their papers or "never had a problem" with a lecturer. The majority of students (81%) said they would like to see other lecturers use mid-semester feedback strategies. The reasons most often cited were:

- It gives students an opportunity to provide feedback.
- If things are not satisfactory, it gives the lecturers a chance to address the problems at a stage that is not too late.

It was interesting to see that one of the students who responded 'no' to this question and another who responded 'yes' gave the same reason: "It takes up lecture time."

End-of-Semester Interviews with Lecturers

Three of the four lecturers attended an interview session scheduled after classes ended. Only one of the lecturers had previously engaged students in an ongoing dialogue about how his class was running. In his second year psychology subject, he reserved an hour on Friday afternoons

for students to informally ask questions, comment on class proceedings, etc. He indicated this effort met with mixed success, primarily due to a low student attendance rate.

Two of the lecturers had made use of the university's student association's class representative system. In this scheme, the class representative asks the lecturer to give a few moments of class time for the representative to talk with the students about the running of the class. The responses are then shared with the lecturer in a private meeting. One of these lecturers had also used the class tutor as an informal source of information about student satisfaction.

Each of the participants complied with the agreement to conduct and respond to a mid-semester feedback exercise. One of the lecturers had the class representative talk with the students. The other two surveyed their classes using the feedback form that the university's teaching and learning support unit had created for this purpose. All three set aside lecture time for discussing the results with the class. In some instances these discussions included a summary display of the student comments, such as "x% of you said I go too slow" while "x% of you said I go too fast." In all instances, the lecturer made some alterations to their teaching and/or explained why they could not adopt other suggestions.

Lecturer A was able to use student feedback to alter her instruction in some very specific ways. In response to student complaints that her overheads were hard to read, she enlarged the font size on her transparencies. She also made an effort to get the lecture notes on the web before the class met and responded to differing students' requests that she either speed up or slow down by covering topics more quickly in class while providing more detailed supporting information via the web notes.

Lecturer B found the discussion extremely valuable and altered his usual practice by setting aside time in two other class sessions for talking with students about how the class was running.

Lecturer C was happy to accommodate student requests that she provide more guidance with the readings. However, the technique she tried was not successful because the students did not come to class prepared. (They were to participate in a discussion that required their having read and processed the required journal articles or textbook chapters before coming to class.) Thus, she had to revert to a lecture format to ensure that students had the knowledge needed to have a meaningful conversation.

When asked how the students reacted to their explanations of why they could not adopt some of the student suggestions, the lecturers reported that the classroom atmosphere seemed accepting, but they could not really know what their students were thinking.

The questions of key interest to the researchers were "How did this exercise affect your satisfaction with the teaching and learning process?" and "Will you do this again?"

Lecturer A said that as a result of the feedback exercise she felt closer to the students and felt there was better and more interaction within the class. Lecturer B indicated that he felt this had been a positive experience for him because he felt more relaxed with the students and, in general, felt the

classroom was a friendlier place. Lecturer C agreed with the first two comments.

All said they would definitely continue using the mid-term feedback strategy, though Lecturer C held some reservations. She said that if she were to do this in the future with another second or third-year class, she would ensure that she again had a good student representative to lead the discussions. If she were to do this with a large introductory class (which she did not in this project), she could see that distribution of a survey would be a more effective method for getting feedback from students.

Lecturer C appreciated that this exercise stressed the idea of gathering 'feedback', which is a better term for this informal approach than 'evaluation.' However, she thought that the connotation could be further improved by referring to it a 'conversation' or 'dialogue'. Feedback and evaluation imply that one is seeking negative comments, whereas holding a conversation does not hint towards such an agenda and, indeed, indicates that both students and lecturers are "on the same side."

Conclusions

Participating students and lecturers generally found the mid-semester feedback exercise to be a positive experience. Students were glad to have an opportunity to voice their opinions at a time when mid-course corrections were possible. Lecturers felt there was an improvement in the lines of communication, resulting in a friendlier, more open teaching and learning environment.

The findings of this exercise will be used to encourage other academic staff to conduct mid-semester "conversation" with their students. This will be promoted via campus newsletters, teaching/learning seminar discussions, and informal conversations with groups or individual members of academic staff.

A continuing issue is the reluctance of academics to participate in a mid-semester feedback exercise. Is this because lecturers see little value in gaining student feedback? Is it because they don't want to give up class time due pressure to cover the maximum amount of content in shortened semesters? Or is it simply suspicion of the existence of ulterior motives? Marincovich (1999) strongly supports the argument that mid-semester feedback should not be used for making evaluative personnel decisions:

> Let me emphasize that the results of any alternate student feedback system should remain formative and confidential. Otherwise, alternative student feedback systems may suffer the same fate the end-of-term evaluations have. The end-of-term ratings began as formative feedback; they became summative when colleges and universities found themselves needing an objective and quantifiable source of data on teaching that would help them make sensitive and important personnel decisions.

Judging from our experience with this study, and selected readings in the literature, the keys to successfully engaging in a mid-semester feedback exercise with students are:

- Establishing the ground rule that this exercise is for formative purposes only. It should be viewed as an opportunity for conversation between students and lecturer. All

results are to be confidential to the participants.

- Asking students for simple, yet specific behaviourally-oriented information. The questions on the mid-semester form used by lecturers participating in this study were:
    1. What helps your learning in this class?
    2. What obstacles are there to your learning in this class?
    3. What could be changed to help you learn better?
- Setting aside a specific time to thank students for their comments and to respond to them. Students want to know that you take their comments seriously. Indeed, don't bother asking for their opinions if you have no intention of responding to them or feel that you cannot maintain a positive and accepting attitude when discussing the results.
- When responding to student feedback, concentrate on ideas or issues that are problematic for a large number or a subset of students having difficulty. Don't allow yourself to be devastated by one or two students' unfair comments. We all have students who are generally disgruntled at one time or another. Their comments may have more to say about themselves than about you.
- Taking a tinkering approach with any changes you choose to make. Marincovich suggests, "Make small, modest changes and don't abandon a change the first time it doesn't seem successful. Tinker with it, making little adjustments, and see if it can be made successful after all."
- When discussing a teaching strategy that you cannot change, give your rationale for doing so. Students will accept a reasonable explanation as long as it doesn't just sound like "an excuse."

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The Scholarship of Teaching and Learning: Lessons from—Gasp!—Sigmund Freud

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Abstract

Although perhaps not immediately apparent, a close analogy exists between the Scholarship of Teaching and Learning (SoTL) and key aspects of psychoanalytic research, theory, and practice. This paper explores how the latter may inform our approach to, and understanding of, the former by focusing on Sigmund Freud's definition of "data" and "the problem," his attention to everyday observations and the "what is," his pursuit of the question "why," his persistence and creativity when confronted with obstacles to his work, his determination to make the unconscious conscious and the invisible visible, and his insistence that his patients "show their work" by thinking out loud.

At the turn of the 21st century, it has become fashionable to pronounce psychoanalytic theory and the therapeutic method of psychoanalysis as passé, obsolete, perhaps even archaic. Sigmund Freud, the father of psychoanalysis, is often dismissed out of hand, if not outright attacked and ridiculed, as a narrow-minded, sex focused, male chauvinist who, among his other failings, possessed little insight into the psychology of women.

I have a different perspective on Sigmund Freud. He was, in my opinion, a genius. Just like the rest of us, however, Freud had his good days and his bad days; his good days were very, very good and his bad days (e.g., his theories about women) were often very, very bad. Nevertheless, on his good days Freud produced a body of thought and work that has become so well accepted and inculcated into our thinking about human psychology that many people no longer recognize the Freudian origin of these tenets. The concepts of the unconscious, psychic and historical determinism, making the unconscious conscious—all these and more have withstood the test of time and proven themselves of enormous heuristic value. Furthermore, Freud's legacy extends even beyond these psychological concepts to the legitimization of a particular research attitude and approach: the detached observation and exploration of everyday psychological phenomena, of matters others often considered to be too insignificant to be worthy of investigation. Thus, one need not accept all of Freud's propositions to benefit from his genius.

As a psychiatrist and medical educator, I have become increasingly aware of the close analogy that exists between the Scholarship of Teaching and Learning (SoTL) and key aspects of psychoanalytic research, theory, and practice. My objective in this paper is explore some points of convergence between the Scholarship of Teaching and Learning, on the one hand, and psychoanalysis, on the other, underscoring how the latter may inform our approach to, and understanding of, the former.

Definition of "Problems," "Research Questions," and "Data"

Freud was a scientist; indeed, his first love was neurology and the science of the human brain rather than the psychology of the mind. He turned to the investigation of the latter not because he had lost his enthusiasm for science but because he recognized that in the late 1800's and early 1900's researchers did not possess the scientific and analytical tools to usefully study the brain. Were Freud alive today, in an era of CT, MRI, and PET brain scans, he might never give psychoanalysis another look.

When he turned his attention to the psychology of the mind, however, Freud did not dispense with his devotion to the scientific method. Instead, he adapted this attitude of thought and methodology to a new set of problems. Thus, in the domain of human psychology, Freud redefined the meaning of a "research question" and of the very "data" on which such research would be based. He legitimized the scientific study of the world of the mind and especially the unconscious mind, as opposed to the brain. The "data," in this paradigm, were not molecules, cells, electromagnetic radiation, the sun or

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distant planets; they were, instead, thoughts and feelings, as well as observable behaviors. The latter had been, and continued to be, the focus of the more traditional psychologists of the time.

In accomplishing this reconceptualization of relevant "data" in the study of human psychology—from observable behavior to the thoughts, feelings, and psychological processes of the mind—Freud focused on details. He adopted an attitude of curiosity and suspended judgment. Nothing was too small, insignificant, embarrassing, or disagreeable to be considered unworthy of study. Whereas most scientists and the public at large of the time dismissed such phenomena as forgetting names, slips of the tongue, and dreams as either unimportant or meaningless, Freud took a neutral, scientific approach, asking himself whether the assumption of research unworthiness was appropriate. For Freud, the fundamental research question was, "Why?" "Why did this particular thought, feeling, or behavior occur, and why now as opposed to some other time?" "Why to this particular person in this particular situation?" "Is there possibly a pattern or deeper significance to these phenomena?" "Might they have meaning beyond what is apparent on the surface?" "How can these phenomena be used to understand the psychology—in contrast to the biology—of the mind?"

Freud did not initially assume that all observable phenomena were relevant or useful; he merely insisted that they should not be dismissed without appropriate investigation. Indeed, the quotation most often attributed to Freud—"Sometimes a cigar is just a cigar"—underscores his recognition that not all thoughts, feelings, or behavior reveal deeper, hitherto unelicited, psychological processes. The proviso, however, is that one cannot confidently say that this particular cigar is "just" a cigar without further exploration and analysis. In fact, Freudian psychotherapists are very suspicious of the word "just," as in "That's just the way I am" or "That's just the way I feel." It may well be true that this is the way one is or that is how one feels; but, from a Freudian perspective, there are reasons, purpose, and meaning behind such observations.

Take, for example, the well accepted notion of the "Freudian slip." Freud concluded that such slips were psychically determined, that is, rather than being random, insignificant events they were the result of structured mental processes that had meaning and purpose. In contrast, most of Freud's contemporaries dismissed such slips as mere mental lapses, temporary mental or speech aberrations with no greater significance.

A psychiatrist, not unlike the author of this paper, was engaged to be married to a woman who was, herself, training to become a psychiatrist. Shortly before the wedding, as the inevitable family, occupational, and academic tensions increased, he and his fiancée had an argument in the course of which the psychiatrist committed a "Freudian slip." In discussing the impending nuptials, he misspoke himself, referring to "our funeral" rather than "our wedding." Hmmmm. Of the hundreds and thousands of words that the psychiatrist might have mistakenly used in lieu of "wedding"—windmill, rutabaga, justice, frankfurter, interest rates—he, or his mind, just happened to choose "funeral." What's a fiancée, in this case a future psychiatrist, to do? Should she attend to this data with its inescapable

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interpretation? In this case the fiancée did what she would often do thereafter in the marriage to bail out her husband; she simply pretended she hadn't heard this blasphemous remark. Freud's point: this apparently innocent slip of the tongue quite clearly had underlying meaning and purpose and was by no means random; most anyone would conclude that, at that moment at least, the groom-to-be had plenty of negative feelings about the upcoming wedding.

It is often on the basis of these everyday observations that hypotheses—trial explanations—are formed that address the central question of "why?" If, indeed, slips of the tongue are not random events but psychically determined phenomena, then how can we explain their existence and function? Freud's investigation into the possible significance and meaning of previously dismissed phenomena such as forgetting names, slips of the tongue, and dreams was a primary factor in his construction of the notion of the "unconscious." Indeed, Freud was almost forced to conceptualize an unconscious mind in order to explain his observations. Simple everyday events ultimately resulted in a complex theory of the human mind that encompassed notions of psychic structure (e.g., consciousness, preconsciousness, and the unconscious as well as the id, ego, and superego) and mental processes or function (e.g., repression, sublimation, and defense mechanisms such as reaction formation, identification with the aggressor, or denial).

Good scholarship of teaching and learning reflects an analogous receptivity to many kinds of data, often in the form of apparently minor observations or details. It requires an open and curious mind that asks, "What might this mean; how can this help me better understand how people learn and how I should teach?"

A communications professor recently told me that after his department had decided to require the use of PowerPoint slides in all departmental lectures, the students' grades, and understanding of the material, actually decreased. The students "just happened" to learn less with PowerPoint lectures? Perhaps, but the dedicated scholar of teaching and learning proceeds to investigate and ask questions. If the observations about the effect of PowerPoint teaching are correct, why is that so; Why did the students do poorly after switching to PowerPoint-based lectures? Was it the number of slides, or the way they were presented, or the use of too many transitions or animations? Perhaps the reduction in learning had less to do with the nature of the slides themselves than the fact that, by not using a blackboard, the instructors were moving faster in covering their material, overwhelming the students. Another hypothesis: by presenting material in such a highly organized manner, students were deprived of the opportunity to organize the material in the way that works best for them; after all, cognitive psychologists have demonstrated that memory, at least, is enhanced by organization of materials but organization imposed by the learner enhances memory more than organization imposed by the instructor. On the other hand, maybe the professors were somehow less enthusiastic and spontaneous about their teaching when scripted by a PowerPoint presentation. Is it possible that the concise summarization of ideas offered by PowerPoint deprived students of the opportunity to hear their professors think out loud, to show how they approach and work through a

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problem? In fact, none, some, or all of these explanations may be correct, and there may well exist other relevant factors that have not even been considered.

All of these questions represent testable hypotheses that might be investigated through rigorous and thoughtful research. Furthermore, each of these questions forces consideration of larger theories: how do students learn; what sorts of things enhance or inhibit learning in particular situations; how does subject matter or discipline influence effective teaching and high-level learning. By giving serious thought to the simple observation that grades went down after the institution of PowerPoint presentations, the willing scholar of teaching and learning is forced to consider what he or she knows about learning in general. The research question ("problem") has expanded from the more narrow concern about the efficacy of PowerPoint presentations to a much broader consideration of how people learn and how best to teach. Observations lead to questions and hypotheses which promote more observations, more questions, and refinement of explanations or theories in an iterative, expansive way. There is an oscillation between observation, exploration, and confirmation as well as between inductive (from a particular instance to a general theory) and deductive (from a general theory to a particular instance) reasoning. In this respect the scholarship of teaching and learning (and Freud's work), is no different than the process of discovery in the sciences and the arts generally.

Lessons to Be Learned

1. Good SoTL often begins with observations of everyday phenomena: it is through the details of ordinary teaching and learning experiences that deeper understanding often evolves.
2. The crucial question is "Why?" Why does this teaching method work or not work; why are students learning or not learning in this particular environment; why do students learn and why do teachers teach as they do?
3. In order to address the question of "why" with respect to teaching and learning, one must observe, formulate hypotheses and theories, and test, alternating between inductive reasoning and deductive research.

Turning Problems or Obstacles into Scholarly Opportunities

Freud, like all successful researchers in the arts and sciences, possessed two critical personality characteristics of relevance to this discussion of SoTL: persistence and creativity. Indeed, although at times very depressed about the progress of his work, Freud persevered; and, in the process, he used his creative mind to transform apparent problems and obstacles into critical discoveries. Let me provide a specific example.

"Anna O." (Breuer & Freud, 1966) was one of the first patients whose case inspired Freud to eventually formulate his theories, but her "psychoanalyst"—this was before "psychoanalysis" as such formally existed—was another physician named Josef Breuer. Although ultimately destined to become a pioneer in social work and women's issues under her real name of Bertha Pappenheim, in the early 1880's, "Anna O." was a very disturbed young woman who apparently suffered from classic "hysteria." She exhibited a wide range of seemingly inexplicable physical

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symptoms and other mental abnormalities. It was Josef Breuer, not Freud, who attempted to treat Anna O. with a cathartic or abreactive method that involved bringing to consciousness previously forgotten traumatic memories. In the end, however, Breuer abruptly discontinued his treatment with Anna O., went on vacation, and subsequently returned to his medical practice, never to engage in psychoanalytic therapy again.

The usual explanation for Breuer's decision to break off his cathartic treatment with Anna O. and ultimately discontinue work with Freud was that he disagreed with the latter's insistence on the central importance of sexuality in the etiology of hysteria. Freud, however, believed that additional factors were critical in Breuer's actions. Indeed, it appears that Breuer had become increasingly transfixed with his patient, Anna O., and spent many hours with her. The final blow, however, according to Freud, was that Anna O. fell in love with Breuer, developed symptoms of a false pregnancy, and insisted that Breuer himself was the father of her unborn child. This disturbing development, in conjunction with his wife's increasing jealousy of her husband's focus on his patient, led to Breuer's abrupt termination of the treatment and departure from the embryonic psychoanalytic movement.

Especially in Victorian times, it is not surprising that Josef Breuer reacted defensively to Anna O's infatuation with him and claim that he had impregnated her. Nevertheless, Freud implied that Breuer was so frightened by these developments that he metaphorically took the next train to Salzburg, in effect saying to himself, "Patients undergoing this cathartic treatment get too weird, and I'm getting out of this business." For Breuer, Anna O's reaction to him was a "problem" and an apparent obstacle to cathartic treatment, leading him to give up on this aspect of his medical work. Freud, however, responded differently, providing us with a valuable lesson that has implications for the scholarship of teaching and learning. Whereas Breuer gave up in the face of an apparently insurmountable problem in his treatment method, Freud took an approach of curiosity: "That's funny; I wonder why Anna O. fell in love with her doctor? Perhaps something important is happening here that I should explore." Chessick (Chessick, 1980, p. 46) underscores this point:

> "A crucial demonstration of the difference between Freud and Breuer occurred during this period when a patient suddenly flung her arms around Freud's neck—'an unexpected contretemps fortunately remedied by the entrance of a servant' …. Rather than retreating, Freud regarded this problem of the erotic transference as one of scientific interest and recognized its great importance in the psychotherapy of hysteria."

Freud's decision to confront and investigate the "problem," rather than to run from it, eventually resulted in the discovery of transference, a cornerstone of classical psychoanalysis and a concept that has broad implications far beyond psychotherapy itself. In the case of Anna O., Freud came to realize that the patient was not perceiving, and reacting to, Breuer as the man he really was; instead, she was relating to him as if he were her father. With the acquisition of this understanding, aided

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by his work with other patients, Freud conceived the theory of transference, that an individual often projects characteristics on to other people based on his or her relationships with past significant figures (e.g., one's parents). While I recognize that for the psychotherapeutically sophisticated reader this explanation is disturbingly simple, it nonetheless underscores the essential lesson. Freud transformed the "problem" of a patient's very strange reaction to treatment into a focus of research and a vehicle to future discovery and invaluable understanding.

Randy Bass (Bass, 1999, p. 1) describes an analogous process in the scholarship of teaching and learning.

> "One telling measure of how differently teaching is regarded from traditional scholarship or research within the academy is what a difference it makes to have a 'problem' in one versus the other. In scholarship and research, having a 'problem' is at the heart of the investigative process; it is the compound of the generative questions around which all creative and productive activity revolves. But in one's teaching, a 'problem' is something you don't what to have, and if you have one, you probably want to fix it. Asking a colleague about a problem in his or her research is an invitation; asking about a problem in one's teaching would probably seem like an accusation. Changing the status of the problem in teaching from terminal remediation to ongoing investigation is precisely what the movement for a scholarship of teaching is all about. … How might we think of teaching practice, and the evidence of student learning, as problems to be investigated, analyzed, represented, and debated?"

Thus, SoTL, like psychoanalysis, requires the neutrality of a scientific researcher, a suspension of judgment until the data are in, an attitude of curiosity and wonder rather than condemnation or embarrassment. It is not that the SoTL researcher is unenthusiastic about his discipline and his work; rather, he eschews pejorative views of apparently ineffective teaching or poor learning outcomes, instead asking, "What happened here and why?"

Are your student evaluations down this year? Perhaps you are just losing your grip, or maybe this particular group of students simply lacked sufficient interest in your subject domain. But before you rush to judgment, about yourself (or your students), ask yourself "why" your evaluations were poorer this year. Your great new teaching idea turned out to be a total bust? Before you turn away from your colleagues and fellow teachers in abject embarrassment, an "educational autopsy" might be in order. Ask yourself how this experience might help you understand how students learn and how we should teach. Just as a physician uses a medical autopsy to learn more about disease and how best it can be treated, so, too, can educators learn from their apparent mistakes or disappointments by asking themselves what did and did not work, and why. Apparent obstacles and difficulties in teaching and learning are precisely the "stuff" of SoTL. Today's obstacles may represent tomorrow's new understandings and next year's more effective teaching methodologies.

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Lessons to Be Learned

4. Difficulties in teaching or deficiencies in learning may be "problems" but they need not be viewed as personal embarrassments or failures. Instead, they represent potential research questions and important opportunities for discovery.
5. Perform "educational autopsies" on your teaching, both when it goes well and when it goes poorly. Ask yourself in each instance, why?

An Unconscious Mental Life and Making the Invisible Visible

Many individuals prior to Freud, from philosophers and religious figures to playwrights and authors, embraced and explored the notion of an unconscious, even if they did not necessarily use that particular label or taxonomy of the human mind. But it was Sigmund Freud who took the idea of an unconscious mental life and structured it, explored it, integrated it into a larger schema of normal and abnormal psychology, and inserted it into the popular culture. Freud believed that an individual's conscious thoughts and feelings were merely the tip of an iceberg; the vast majority of mental life proceeded in the unconscious, under the surface and beneath conscious awareness. Not only was the majority of one's thoughts, feelings, fantasies, wishes, and fears to be found in the unconscious; but, according to Freud, more often than not one's behavior was more powerfully motivated by unconscious than conscious thoughts and feelings. Thus, Freud set out to explore the unconscious mind of man. In the process of psychoanalytic psychotherapy, Freud's goal was to make the unconscious conscious. He believed that by doing so, a person could exert more rational control over his inner thoughts and feelings.

SoTL is very much like psychoanalysis in this regard. It seeks to make the invisible visible, to make transparent the hidden mental processes of the student so as to enhance teachers' ability to teach and learners' ability to learn. And, like Freud's belief that most of mental life occurs beneath the surface, out of view of ordinary observation, most SoTL investigators would advocate a similar finding in their field. The vast majority of learning occurs in the absence of a teacher, and even that learning that occurs in a classroom setting is often hidden to the teacher (and the student or learner himself) in the form of unconscious mental processes. How does a student organize knowledge, what does he recognize as relevant "data," what mechanisms does he use to remember or apply ideas and concepts–each of these questions relates to mental activities that occasionally occur explicitly but more often implicitly and unconsciously.

Making visible the invisible learning that occurs in a student poses some of the same difficulties as does making a psychoanalytic patient's unconscious thoughts and feelings conscious. In both cases, we are unable to directly observe the internal mental processes as they occur; instead, we must rely on the observation of "derivatives" in order to make inferences about hidden mental processes.

Let me provide a common medical example of the use of derivatives to make visible something that is otherwise invisible. Physicians frequently make the diagnosis of pneumonia in their patients, but rare indeed is the primary

care physician who actually "sees" the patient's pneumonia. After all, to see a patient's pneumonia one would have to actually look at lung tissue and find signs of inflammation such as white blood cells and pus. To do this, a physician most likely would have to be either a pathologist performing an autopsy on a deceased patient (a little late, perhaps, for a therapeutic intervention) or a pulmonologist (lung specialist) using a bronchoscope (in effect, a fiber optic TV camera that is placed in the patient's lungs via the windpipe). And yet thousands of physicians make diagnoses of pneumonia every year, and they are often correct. How do they do it?

The answer is, they use derivatives of pneumonia to infer its presence. What are such derivatives? They consist of symptoms (physical abnormalities reported by the patient such as fever, cough, and production of green sputum), signs (physical findings of pneumonia as detected by the physician such as thermometer-determined fever and abnormal breath sounds when listening with a stethoscope), and laboratory/radiographic findings (such as an elevated white blood count cell or an abnormal chest X-ray). Note that in the latter instance, (as I must frequently remind medical students) one rarely literally "sees a pneumonia on chest X-ray" unless a sloppy pathologist has inadvertently placed a piece of pneumonic lung on a chest X-ray lying on a desk. Instead, what one sees are only lines and shadows, but the trained physician recognizes that certain constellations of lines and shadows found on X-rays of the chest reliably suggest, but do not prove, pneumonia. Similarly, when putting all of the above derivatives together, one becomes almost certain of the presence of pneumonia, although the physician has not and does not actually directly observe the disease.

The same holds true for psychoanalysis where the processes and contents of the unconscious mind are, by definition, invisible. Yet, those processes and contents can be reliably inferred if sufficient numbers of derivatives from a variety of domains and of sufficient certainty can be elicited, noted, and appropriately synthesized. Although Freud referred to dream interpretation as the "royal road to the unconscious," he recognized the utility of free association, transference, and other techniques and phenomena for making the unconscious conscious. Psychoanalytic terminology notwithstanding, what Freud was saying in essence was that the content and workings of the unconscious mind can be uncovered and clarified by its derivatives: one's conscious thoughts, feelings, behaviors, and symptoms.

A thirty-six-year-old woman marries her fourth alcoholic husband. Could this behavior represent an unconscious wish to marry a man like her alcoholic father and attempt to reform him as she had been unable to do with her own father? A meek accountant has obsessional fantasies of a violent intruder breaking into his house and murdering his family, thoughts that he finds very disturbing. Is it possible that these obsessional thoughts reflect the accountant's unconscious but very real hostility toward his wife, something that he is unable to consciously acknowledge to himself, much less to her? A law student becomes depressed every time he does well on an examination. Does he unconsciously feel guilty for trying to outdo his father who never graduated from high school?

SoTL researchers face similar tasks and challenges in that, like psychoanalysts, they, too, must attempt to make visible the invisible thoughts of others, in this instance, the invisible thought processes of their students while attempting to learn. To understand, and ultimately enhance, students' learning, it is necessary to focus on the very thought processes involved in learning: what factors control attention; how is presented knowledge perceived; what are the mechanisms by which information is encoded and stored in working and long-term memory; what conceptual schemas or maps are utilized by learners so as to make knowledge available for recall and application; how does emotion influence memory and learning; how do novices and experts differ in the way they reason when presented with a relevant problem? These are but a few of the many questions reflecting mental processes that are at least partly invisible that SoTL researchers must address in order to truly understand how their students learn and how their teaching might be enhanced.

Moreover, again in direct analogy to the work of the psychoanalyst, the SoTL researcher must identify relevant and reliable derivatives—or proxies—for the learning processes that are occurring invisibly in his or her learners. Of course, tests—multiple choice, essay, or practical exams—are the most common way we attempt to infer what learning processes have occurred, but such tests typically tell us more about the outcome of attempted teaching and learning rather than the process of learning itself. What are examples of more useful learning derivatives?

Let me return to the question of the effect of PowerPoint-enhanced lectures on learning. The work of cognitive psychologists has demonstrated that organization of information is critical to its ultimate recall, comprehension, and application to actual problems or issues. (Anderson, 2000; Sousa, 2001) However, as previously noted, it is also true that information organized by learners themselves is better remembered and utilized than is already organized information presented to learners. Organization of knowledge is important, but self-organized knowledge is even more useful than, in the context of this discussion, teacher-organized knowledge. As I suggested earlier, perhaps polished PowerPoint presentations, typically presented in rapid-fire fashion, do not allow the individual student time to think about the information and organize it in ways that make sense to him or her.

In order to test this hypothesis, the SoTL researcher might search for intermediate or process artifacts—derivatives or proxies—that elucidate these relationships. For example, two groups of students might be presented a series of lectures; in one group PowerPoint is used while in the other the instructor speaks off the cuff, perhaps even using the entirely antiquated technology of the blackboard. Thereafter, students might be asked to construct concept maps of what they have learned. How might these maps differ among the two groups of students? In this instance, concept maps serve to elucidate how students actually organize the information presented to them; they are an intermediate step in the learning process and are an important proxy of the learning itself.

Another example of learning derivatives: students' misconceptions about a particular subject or concept are powerful obstacles to learning, and they

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often operate invisibly, but inexorably, in the mind of the learner. Good teachers know how vital it is to bring these misconceptions out into the open where they can be addressed. Such misconceptions, whether brought to a particular subject a priori or formed in the course of a class or discussion, represent another type of intermediate artifact, a variant on the concept maps discussed previously. Once again, learners and psychoanalytic patients, as well as teachers and psychoanalysts, have similar challenges. Just as a patient's distorted, and often unconscious, beliefs about himself, others, or the world powerfully affect his everyday thoughts, feelings, and behavior, so, too, do the often unacknowledged or unconscious misconceptions of students prevent appropriate learning. In both instances, the task of the teacher or psychoanalyst is to bring such distortions or misconceptions to light—to make the unconscious conscious and the invisible visible—so that they can be openly addressed and modified.

Concept maps and misconceptions represent too examples of learning derivatives or proxies, but they are hardly the only two such examples. Nevertheless, they are sufficient to raise the next important SoTL question: how can learning derivatives be uncovered? As I will discuss below, one of the best ways to explore the learning processes that regularly occur beneath the surface is by insisting that learners "show their work."

Lessons to Be Learned

6. In order to advance the Scholarship of Teaching and Learning, educators must make their students' invisible learning processes visible.
7. The means by which learning processes can be elucidated, understood, and ultimately enhanced, is through the use of learning derivatives or proxies.

Freud's Fundamental Rule: Show Your Work

Freud realized that he could not gain direct access to the workings of the inner mind simply by observing behavior or mental symptoms. Thus, as described above, he set about exploring the derivatives of mental life: the statements, emotions, behaviors, and symptoms through which an individual reveals his or her unconscious thoughts, feelings, wishes, fears, and fantasies. In the context of individual psychoanalysis, Freud accomplished this objective by asking his patients to use the technique of free association and to observe the "Fundamental Rule." (Freud, 1913)

Freud's "Fundamental Rule" was that a patient in psychoanalysis should report everything that comes to his or her mind, regardless of how irrelevant, nonsensical, odd, uncomfortable, or even revolting it may appear to be. In effect, Freud insisted that his patients think out loud—in other words, "show their work"—in this case the mental work of the mind. While he recognized that such reports were always edited and distorted, he nonetheless believed that much important information could be gained by this method. While we are rapidly developing techniques for actually visualizing brain structures (CT and MRI scans) and brain function (functional MRI and PET scans), as yet we have no better method for exploring unconscious thoughts, feelings, wishes, and fantasies—the hidden products of the mind.

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The SoTL equivalent of free association is "show your work." By insisting that learners show their thought process, rather than simply produce the correct answer to a given problem or question, educators can gain access to the hidden world of learning that occurs in the mind of the student. The process is analogous to that we all experienced during our many years in math class; in that context, "show your work" meant explicitly recording the various mathematical steps used to reach an answer. The same technique, however, can be applied equally well in other academic disciplines, with the exception that one's "work" is more likely to be demonstrated by the use of words—thinking out loud—rather than algebraic substitutions or mathematical formulas.

There are innumerable methods by which learners can be encouraged to show their work, but if I were to recommend one source for initial reading on this topic, I would suggest Teaching for Understanding. (Wiske, 1998) The authors, all participants in Harvard Project Zero, propose four basic dimensions of understanding (knowledge, methods, purposes, and forms) as well as four levels of understanding (naïve, novice, apprentice, and master) within each dimension. Their schema provides a very useful template by which educators can assess their learners' understanding through the utilization of the "show your work" principle.

Whatever mechanisms one chooses to encourage students to show their work or, if you will, think out load, the ultimate outcome is answers to the crucial question of "what is?" "What is" here refers to the explicit and implicit aspects of learning, the visible and invisible processes by which students acquire and manipulate knowledge so as to be "learned." Mapping the terrain of "what is" with respect to student learning processes—thinking, memorizing, organizing, conceptualizing, analyzing, synthesizing—is a descriptive endeavor wholly analogous to Freud's efforts to understand the structure of the human mind by first exploring exactly what it was his patients were thinking, feeling, and experiencing. Freud was well aware that he could not hypothesize in a vacuum; observations (e.g. patients' mood and behavior), known phenomena (e.g., slips of the tongue and dreams), and empirical "facts" (revealed, for example, by the process of free association) provided the fuel for subsequent theorization. Similarly, only with the "facts" of the learning process can educational researchers make and test hypotheses, construct larger theories, and intentionally and intelligently manipulate variables so as to enhance teaching and learning.

Eliciting the empirical facts of the learning process—the "what is"—by having students think out loud and show their work provides an important check against unwarranted assumptions as to what we, as teachers, are doing as well as to what works, and why. An interesting psychiatric book, in this regard, is Every Day Gets a Little Closer: A Twice Told Therapy (Yalom & Elkin, 1974) by Irvin Yalom, a psychiatrist, and Ginny Elkin, one of his patients. The book consists of simultaneous therapy notes produced by both Doctor Yalom and by Ginny Elkin, an author by trade. To Dr. Yalom's surprise and chagrin, he learned that some of his most "brilliant" interventions, at least from his perspective, appeared to have had no effect whatsoever on his patient; conversely, behaviors on his part that he considered to be unimportant were of great significance to the patient. The

moral is clear: one assumes he understands what works and why at his peril. Only thoughtful and thorough research reliably elucidate processes of cause and effect, whether they be psychotherapeutic or educational.

Lessons to Be Learned

8. The most direct way to observe and understand the learning process is to ask learners to "show their work."
9. Use the "what is" of learning processes to hypothesize and test, theorize and validate so as to be able to enhance teaching and learning.
10. Beware of assuming educational cause and effect; only appropriate research can establish such connections.

Conclusion

Were Sigmund Freud alive today, would he eschew the study of psychoanalysis for the scholarship of teaching and learning? Of course not! Nevertheless, those interested in SoTL have much to learn from Freud's example. His redefinition of "data" and "the problem," his attention to everyday observations so as to clarify the "what is" of his patients' psychological landscape, his relentless pursuit of the question "why," his persistence and creativity in the face of apparent obstacles, his focus on making the unconscious conscious and the invisible visible, his use of "derivatives" to study mental processes not directly observable, and his insistence that his patient's "show their work" by thinking out loud are all valuable models equally applicable to SoTL and the study of human psychology.

So [said the doctor]. Now vee may perhaps to begin Yes

Philip Roth, *Portnoy's Complaint*

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"Doing" Phenomenological Research: Connecting Nursing Education, Research, and Professional Practice

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Abstract

The interactive practices associated with faculty teaching and students learning to conduct phenomenological research provided an important opportunity for advanced practice nursing students to reevaluate their worldview of patient care and the lived experience of health and illness. Further, these students demonstrated transformation in their personal perspectives on nursing education, research, and practice. The investigators examined a variety of classroom action outcomes to explore the effectiveness of current teaching strategies in our master's research study course.

To describe graduate students' new understandings of health care, nurse educators analyzed self-evaluation documents and reflective narratives from masters nursing students who were learning to conduct phenomenological research. The following themes were identified (a) finding the exceptional in the routine, (b) resonating with stories of health and illness, and (c) putting this research into daily practice. We conclude that "doing" phenomenology not only results in excellent clinical research directly applicable to nursing practice, but also served to transform the professional practice perspectives of graduate student nurses engaged in this research methodology.

Since Florence Nightingale's time, efforts have been made to unite the conversations between nursing education, research, and practice on a grand scale (1859/1969). Unfortunately, the interrelationships between these three aspects of the nursing profession remain elusive and these topics are often addressed as if each were unrelated to the others. The investigators found the classroom actions for completing phenomenological research resulted in student research that was philosophically grounded, methodologically sound, and useful to nurses caring for individuals and families with chronic illness. Further, the students described how the activities associated with actually doing phenomenological research resulted in transformation of their personal perspectives on nursing education, research, and practice. Further, they developed new understandings of patient care and the lived experience of health and illness.

The investigators used interpretive phenomenology to explore the many facets of the students' self-described transformation through doing phenomenological research. The following themes were identified: (a) finding the exceptional in the routine, (b) resonating with stories of health and illness, and (c) putting this research into daily practice.

Classroom Actions for Students Learning to Conduct Phenomenological Research

Adult and family nurse practitioner students completed eight months of independent research in clinical areas of their choosing to meet the final requirements for the masters in nursing science degree. These projects were approved by the Indiana University Human Studies Committee. To date, thirty-five students have participated in the phenomenological research option. Phenomenological research is useful in describing and understanding a human experience (phenomenon) through analysis of narrative text. Heidegger's (1962) phenomenological view of the person centered on "lived experience" as an interpretation of the person in relation to his world, as a being for whom things and events have significance and value, and as the experience of things and events as they are self-interpreted through the person's perception and interpretation of physical body experiences, time, and those things they care about (Leonard, 1994).

Students used interpretive phenomenology methods to understand the phenomenon of chronic illness. The investigators used the same methods to explore the phenomena of students learning to use phenomenology methods of research. The objective of the course was to teach students to conduct nursing research using a phenomenological approach. From a classroom action research perspective (Mettetal, 2001), our question was to discover what other form(s) of learning were outcomes of these traditional research training activities.

Students met as a group on a weekly basis for round table discussions regarding their research projects. These were facilitated by the investigators in our roles as co-teachers. Classroom discussions addressed phenomenological research philosophies, methods, and analysis procedures. Early in the learning process, both students and teachers

offered stories of their own nursing education, practice experiences, and personal experiences with health and illness. These served to bring light to shared meanings and common practices found within our own lived experiences with health and illness.

Each student selected individuals with chronic illnesses as participants in his or her research study. Family members were invited to share their experiences as well. Each student engaged his or her participants in in-depth tape-recorded interviews lasting from 1-2 hours each. The interviews were transcribed verbatim and shared with the other students and teachers. The students and teachers read and made independent analyses of each transcript (Diekelmann, Allen & Tanner, 1989). Over the next several months, the students and faculty shared their analyses, made suggestions, and offered readings and literature reviews useful to other students. The expected outcome of this process was accomplished as each student developed his or her own analysis, produced a manuscript of the research findings from his or her own data, and connected the conceptualizations of the individual narratives across all the interviews.

Methods for Classroom Action Research Study of Lived Experience of Doing Phenomenological Research

Data for the present study were gathered from (a) group conversations and interactions throughout the students' research experience, (b) through statements of topical presence and reflexive evaluation included in individual completed research papers, (c) from course and teacher evaluations, and (d) from oral comments made to the teachers at the end of coursework. Using the same interpretive analysis techniques (Diekelmann, Allen & Tanner, 1989) employed when analyzing the transcripts from individuals with chronic illness and family members, the investigators analyzed the students' verbal and written narratives and identified themes and patterns involved in this transformative process. In this process narrative data was read numerous times. Themes within each individual narrative were identified. Themes were clustered into patterns, common and recurring phenomena, which appeared in multiple narratives. Patterns are the highest level of findings coming from phenomenological research.

Findings

Initially, students described how having conversations with patients about various illnesses was a hallmark of traditional nursing care and not a new skill for these much experienced graduate nursing students. They recalled how their nursing conversations were focused to discover the "facts" rather than the "meaning" of a patient's particular situation. By the completion of individual research projects, students found new insights in seemingly routine conversations with patients and families. These insights resulted in an enrichment of the students' own practice base and the possibilities of sharing new ideas with other nurses.

Students who engaged in the phenomenological research of chronic illness demonstrated significant insight into the illness experience of their participants. Not only did students

provide narratives from the study participants, they also provided their own personal narratives from doing this research. These personal narratives repeatedly included phrases such as "I will never look at patients the same way again." In learning about health and illness, these students experienced transformation in how they practiced as nurses. We identified three themes related to that transformation including (a) resonating with the stories, (b) finding the exceptional in the routine, and (c) putting this research into practice.

Resonating With the Stories

Heidegger described how learning to resonate with the essence of a lived experience allowed new ways of thinking to come forward (1971, pg. 5):

> As soon as we have the thing before our eyes and in our hearts an ear for the word, thinking prospers.

One of the first assignments was for students to write about a personal experience with a health or illness situation describing the experience and its personal meaning. As students shared these with each other, they began to understand "lived experience" as a significant and unique journey. Each found ways in which another's experience reflected his or her own experience or brought new understandings of the illness experience. They then used these skills to find connections and understandings in the participants' stories of health and illness.

No longer did the students interview participants to gather medical histories. Rather, they participated in "inter-Views" (Kvale, 1996) that allowed new insights into others' stories which resonated with and became part of their own stories as nurses. One described this phenomenon as:

> Listening to and absorbing the life stories, they become a part of my experience and me. Seeing the patient and family at their most vulnerable and weakest times, and sometimes at their best, draws me into their world with an intensity that often only nurses have been privileged to feel.

"Resonating" went beyond seeing or hearing differently. For some, a new bond occurred with patients and nurses as the graduate student nurses came to understand health and illness beyond pathophysiological parameters:

> Listening to their life experiences links me to them. The power of their words describes their roller coaster experiences and the overwhelming constraints in their lives. I will take their words with me as I move in and out of other patients' lives. I will listen more carefully to hear exactly what their illness means to them and their families.
>
> Perhaps I can smooth the jagged edges of adjustment from health to chronic illness for another family ...

Finding the Exceptional in the Routine

Most of our students had long professional experience in caring for patients with various illnesses and

health concerns. In fact they were so experienced they frequently described patient-nurse interactions in language denoting "ordinary" or “routine". Early in the course work, they frequently used proscribed nursing jargon ("inability to care for self secondary to profound mental retardation”) or pathophysiological labels (polymicrogyria, polycystic ovary syndrome, or cardiomyopathy) to describe their patients’ situations. Students also described the “meaning” of these conditions from purely psychosocial or behavioral perspectives (i.e., denial, enmeshment, and noncompliance). These labels reflected an outside-in view of what individuals experience (what one thinks another experiences), rather than the phenomenological inside-out perspective of understanding the unique meaning of the illness experience for those who have chronic illness conditions..

Heidegger described phenomenology as the ability to find the "splendor in the simple" (1971, p. 7). Once students were able to resonate with the stories, they were able to go beyond psychosocial labels. While patients' health problems might be ordinary, the students’ found the lived experiences of participants were powerful and unique. In a study of severe rheumatoid arthritis, one student found:

> [The woman] kept talking about wanting to be normal. I believe that she is anything but normal -- she is exceptional.

Putting This Research into My Practice

As nurse educators, we expected that students would successfully complete their research projects, develop their research papers, and find the research course to be exciting and challenging. We did not anticipate that students’ professional practices would substantively change as a result of doing phenomenological research. Transformation of graduate student nurses’ view of health and illness and how they practiced nursing was an unexpected outcome. An example from a student demonstrated this transformation:

> The lived experience of chronic illness (was) very powerful, forcing me to consider my past care for individuals and their families. Although I have been concerned for them and their "living,” I have rarely attempted to truly understand their experience,. . .In the future I will be better able to truly listen,. . .I believe I will be a more caring person and nurse. Another graduate nursing student wrote: I learned that nursing concerns are not always client concerns,. . .I will always look at each person as different and unique and will treat them as such. I learned new ways to interact with my clients that I had not thought of before. This will help me be less of a black-and-white kind of person and will enable me to see the gray areas as well.

While each student completed satisfactory research papers, not all students experienced a transformation in their worldview of patients and families managing chronic illness.

Reflecting on the students who did not demonstrate transformation in their nursing practice, we found the following. These students commonly described their comfort with rigid empirical design methods, statistical analysis, and validity and reliability assurances. Some students struggled initially in adopting qualitative research philosophies, finally appreciation of the method late in the research process. Others never did find comfort in these methods. These students were not able to incorporate reflective interview skills and their research interviews were not very different from the familiar nursing history taking which had always been part of their nursing practices. These students were in the minority as most of the students actually came to embrace phenomenological research methods, engaged in reflective analysis of their narrative data, and described a transformation in the way they practiced nursing care for individuals and families facing chronic illnesses.

The students described how doing phenomenological research provided them with a means of "seeing with new eyes" or "hearing with new ears". Further, they were able to find concrete ways to change not only their own nursing practices, but the practice of others as well. As one noted:

> I can now play an instrumental role in erasing this stereotyped image (of aging) and replace it with one of an individual who is vibrant and alive.

Conclusions

Graduate nursing students described how active participation in phenomenological research served as a catalyst for them to share their research, education, and practice experiences through conversations with the research team. While the outcome of each student's independent research will advance nursing practice in and of itself, an additional outcome was found in this classroom action research study. Students described how collectively engaging in the interactive process of teaching and learning phenomenological research transformed their individual thinking and changed them as practicing nurses. We find these classroom activities provided graduate student nurses a unique opportunity to connect for themselves the conversations which bridge and enrich nursing education, research, and practice in ways that traditional academic efforts have not been able to provide.

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Using Boyer's Four Forms of Scholarship to Advance Engineering Education

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Abstract

The Center for Engineering Education (CEE) at the Colorado School of Mines promotes both educational research and instructional improvement. In order to connect the potentially competing activities of research and teaching, CEE uses Ernest Boyer's model of the four forms of scholarship to describe and shape sponsored activities. According to Boyer, the word "scholarship" should not only describe the activities of those who conduct original research (which he called the scholarship of discovery) but also the activities of those who integrate and apply knowledge and those who teach. This paper describes Boyer's model and provides examples of how the four forms of scholarship display themselves in CEE sponsored projects and activities.

Based on "The Center for Engineering Education at the Colorado School of Mines: Using Boyer's Four Types of Scholarship" by Ruth A. Streveler, Barbara M. Moskal, and Ronald L. Miller which appeared in the Proceedings of the 31st ASEE/IEEE Frontiers in Education Conference ©2001 IEEE.

Introduction

This paper begins by briefly introducing the Center for Engineering Education (CEE) at the Colorado School of Mines and by describing CEE's mission and goals. Next, Boyer's four forms of scholarship are presented as the framework that was used to guide the development of CEE sponsored projects and activities. This paper concludes with a description of three projects that illustrate all four forms of scholarship. An earlier version of this paper was presented at the Frontiers in Education Conference (Streveler, Moskal & Miller, 2001).

The Center for Engineering Education

The Colorado School of Mines is the second oldest and one of the largest public research universities in mineral engineering and applied science in the country. Although the CSM does not have a School of Education, faculty at CSM have been interested in educational issues and have participated in educational research for over twenty years. To support educational efforts, a new entity was conceptualized in the early 1990's— the Center for Engineering Education (CEE). The purpose of CEE is both to provide professional development opportunities to faculty and graduate students and to foster educational research at CSM. After ten years of discussion, the Center for Engineering Education (CEE) was established in January 2000.

The first task for the new center was to articulate its mission and goals. The mission of CEE is to improve the learning of science and engineering, thereby increasing the accessibility of these disciplines. The goals of CEE are as follows:

1. to conduct world-class research on the teaching and learning in science and engineering,
2. to use the results of that research to continually improve instruction at the Colorado School of Mines to better support the learning process of our students, and
3. to support the educational needs of science and engineering teachers and learners at the K-12, university, and continuing professional development levels.

For a more in-depth discussion of the purpose and goals of CEE, see Streveler, Moskal, Miller, and Pavelich (2001).

Boyer's Model: Four Forms of Scholarship

In Scholarship Reconsidered, Boyer (1990) argued that the intellectual rigor that defines scholarly activities should extend beyond conducting original research and publishing results. Boyer suggested that the same scholarly rigor be applied in four inter-related activities: discovery, integration, application, and teaching. Boyer's framework was immediately recognized as an ideal structure to guide the development of CEE's projects and activities (Streveler, Moskal, and Miller & Pavelich 2001). This section describes each of Boyer's four forms of scholarship. For greater detail concerning these forms of scholarship see Boyer (1990) and Glasic, Huber and Maeroff (1997).

The scholarship of discovery (Boyer, 1990; Glasic, et al., 1997) is the act of creating new knowledge within a given discipline. This is the traditional view of research on college campuses. Discovery is central to the advances of any given discipline and is driven by what an individual investigator or team

of investigators desire to know. Discoveries that impact society have been made in every discipline, including education. Research in cognitive psychology and educational psychology has provided a foundation for understanding how learning takes place (Bransford, Brown & Cocking, 1999; Marra, Palmer & Litzinger, 2000). Efforts have also been made to unveil how learning occurs in undergraduate engineering education (Atman & Bursic, 1998; Marra et al., 2000; Turns, Atman & Adams, 2000).

The scholarship of integration connects or links information between different disciplines and areas of knowledge. Integration is the act of taking facts and concepts that emerge through separate investigations and linking these facts in a meaningful manner. Examining how the principals of cognitive psychology may inform engineering education (or vice versa) is an example of the integration of knowledge. Integration allows the discoveries in one area to inform the discoveries in another area. This type of exchange increases the speed at which new discoveries are made across the different areas of investigation.

The scholarship of application builds upon the scholarship of discovery and the scholarship of integration. After new knowledge is discovered, the question becomes, "how can this knowledge be used?" The findings of cognitive psychology, learning theory, and engineering education may all inform the development of an effective undergraduate engineering program. In this example, it is the scholarship of integration that leads to the scholarship of application. The findings from each of these fields must be integrated before this information can be applied. Engineering courses may also be revised with the results of educational research in mind. Findings from individual studies as well as insights acquired through the integration of information across studies can be used to determine an appropriate structure for an effective engineering classroom.

The scholarship of teaching puts the results of research into action. Effective teachers not only know what factors support the learning process, but also they make an active effort to implement this knowledge in their classrooms. Quality teaching is an on-going process that requires the assessment and evaluation of the impact of innovations on the learning process. Much like research, quality teaching requires the testing and verification of educational hypotheses. The laboratory for the teacher is the classroom.

As this discussion suggests, the four forms of scholarship are not independent, but rather each type of scholarship overlaps and influence the efforts within the other forms of educational scholarship. This will be further illustrated in the next section through the discussion of CEE sponsored projects. This framework for discussing scholarship was presented here with respect to the discipline of education; however, the framework is equally appropriate with respect to any given discipline (Boyer, 1990).

Scholarship at Work

CEE sponsors a number of different programs that support the four forms of scholarship: discovery, integration, application, and teaching. The programs that will be discussed here were selected because they illustrate how all four forms of scholarship can be displayed within a single program or project.

Student Misconceptions in Engineering

Some CEE faculty members are actively exploring the question: “Why are some concepts in science and engineering so difficult for students to learn?” Evidence from the literature in cognitive psychology suggests that science and engineering students do not conceptually understand many fundamental molecular-level phenomena such as heat, light, diffusion, and electricity (Reiner, Slotta, Chi & Resnick, 2000). These types of phenomena are examples of emergent processes or processes that involve uniform, parallel, independent events with no beginning or end.

It has been proposed that the conceptual misunderstandings arise when students incorrectly think of emergent processes as having the attributes of the causal processes that are seen in everyday life (Chi, in press). Causal processes involve distinct, sequential, goal-oriented events that have an observable beginning and end. Consider the example of adding a droplet of colored dye into a beaker of quiescent water. Visually, the dye appears to move through the water until the resulting dye/water mixture has the same color throughout the beaker. This point is called "equilibrium" and it visually appears that there is no further dye movement in the water. This experiment can be incorrectly described using a causal model. A student may explain that the dye molecules “want” to mix with water and that the individual dye molecules move with intent to create a uniform dye/water mixture. After this uniform mixture is created, the student may incorrectly believe that the movement of the molecules has stopped.

A correct conception of this process is that both the dye and water molecules continue to randomly move even after equilibrium is reached. Initially, the dye molecules are concentrated into a small region. As the molecules randomly bounce about, they become thoroughly mixed with the water molecules. This results in a mixture that is visually uniform, but microscopically the molecules continue to move. Students, who describe this complex, dynamic process using the causal explanation, possess a mental model that is fundamentally incommensurate with accepted theories of molecular motion. Since this causal model seems to describe the macroscopic behavior of the dye/water experiment, students are comfortable with this view and hold tightly to this misconception.

Many fundamental topics in science and engineering involve emergent processes, which are often incorrectly viewed by students as causal processes. Students describe molecular momentum transfer as faster molecules “dragging slow molecules along,” heat as a “substance stored in hot objects,” heat transfer as a “flow of hot molecules to cold objects,” and molecular processes as “stopping” when they reach equilibrium (Reiner et al., 2000). None of these explanations are correct and each leads to incorrect explanations of other related phenomena. For example, the assumption that heat transfer is the flow of hot molecules to cold objects leads to the belief that there is an absence of a temperature effect on equilibrium processes. Similarly, the assumption that molecular processes stop at equilibrium leads to the incorrect belief that no molecular diffusion occurs in laminar fluid flow.

Studies are now being formulated at CEE to identify what concepts engineering students find difficult (i.e., scholarship of discovery), what makes these concepts difficult (i.e., scholarship of integration of engineering,

engineering education and cognitive psychology theory), how assessment can be used to identify the existence of student misconceptions (i.e., scholarship of application), and what instructional approaches are necessary to correct these misconceptions (i.e., scholarship of teaching). CEE has received funding from the National Science Foundation for the study, Developing an Outcomes Assessment Instrument for Identifying Engineering Student Misconceptions in Thermal and Transport Sciences (DUE - 0127806), to support this research endeavor. Based on the results of this research, methods of instruction are expected to be created that will help students to better understand emergent processes.

Examination of the above identified project goals reveals the importance of all four forms of scholarship. The project's emphasis is upon the discovery of new knowledge (e.g., what concepts do engineering students find difficult to understand? What makes these concepts difficult to understand?). Responding to these questions, however, requires the integration of knowledge from the fields of engineering, engineering education and cognitive psychology. The results of this project will be applied to the development of assessment instruments to measure student misconceptions. Eventually, the knowledge that is acquired from this project will be used to develop instructional efforts that assist students in developing more appropriate conceptions, the scholarship of teaching.

Gender Difference in Engineering Design

Another CEE project that is underway and is sponsored by the National Science Foundation's Activities for Women and Girls in Science, Engineering & Mathematics program is the Engineering Design Teams: Influence of Gender Composition on the Decision-Making Process project (EHR-9979444). This project examines the team decision-making process in the Engineering Practices Introductory Course Sequence (EPICS) using an observational protocol developed by Eberhardt (Eberhardt, 1987). EPICS is a sequence of required freshmen and sophomore courses at CSM in engineering design.

The purpose of this project is to examine the interactions that take place between men and women during team decision making and categorize these interactions using an instrument that was developed by Eberhardt (1987). This project seeks to address the following research questions: "1) How does the gender composition of a team impact the quality of the developed solution to an ill-structured problem?, 2) How do the roles team members play differ when gender composition of the team varies within the decision-making process?, and 3) How does the gender composition of the team impact upon the quality of the experience reported by team members during the decision-making process?" (Cheney, Lasich & Moskal, 1999, p. 3).

Early results of this project suggest that the gender of individual team members had little impact on the roles that team members played during the team process. This finding is in stark contrast to research in other fields (e.g., Wylie, 1996; Jones, 1999). An explanation for this difference is that women who select to participate in engineering may be different from women who select to participate in other fields. Therefore, it is reasonable to assume that women in engineering will respond to the team process in a manner that is different from women in other fields. An interesting finding of the current

research is that whether a team consisted of more males than females, more females than males or was equally mixed between males and females did have an impact on the roles that team members played during team interaction. For example, male dominated teams were more likely to be witnessed encouraging other team members and clarifying information than were female dominated teams. Male dominated teams were also more likely to be witnessed setting standards than were female dominated teams (for more information concerning these results see Macdonell-Laeser, Moskal, Knecht & Lasich, 2001).

Based on the early results of this study and the research questions, this project appears to involve the scholarship of discovery. However, in order to pursue the research questions described above, an interdisciplinary investigative team was necessary. This team included specialists in engineering education, gender issues, assessment, and communication. Each of these individuals brought to the project the knowledge from their respective field (e.g., the scholarship of integration).

One of the primary reasons for pursuing this research was to acquire information concerning team interactions that could be used to improve the Design EPICS sequence at CSM. In other words, the information that is acquired will be applied to the development of appropriate instructional methods for supporting the design process. This outcome requires both the scholarship of application and the scholarship of teaching.

Preparing Doctoral Students to Teach

A final example of a CEE activity that illustrates all four forms of scholarship is the efforts to educate engineering doctoral students in educational research. CSM has established a 2-credit hour course called “Fundamentals of College Teaching", which is offered to doctoral students who are contemplating a career in academia. Recent literature supports the importance of this effort (Wankat, 1999). This course is offered every year and is taught by three CEE faculty members. Table 1 contains a brief description of the course, a list of the course objectives, and an outline of the course activities.

At first glance, this course appears to focus upon the scholarship of teaching. Students learn about and practice teaching methods. They also read Wilbert McKeachie's classic work Teaching Tips (1999) and they practice teaching techniques through short presentations called "microteaching." For each microteaching presentation, faculty members provide the students with suggestions for improving their instructional techniques.

Examining this course beyond its surface features, however, reveals that all four forms of scholarship are at work. The students in this course are working on their doctorate and therefore, are deeply involved in original research projects. The course instructors encourage these students to develop their microteaching assignments around their own research results. Thus, the scholarship of discovery is brought into the course.

The initial topic discussed in the course is how people learn. This discussion is motivated by readings from Bransford, Brown & Cocking's (1999) book, How People Learn. Students in the course learn how knowledge is organized, how the organization changes as one gains expertise in the field, and the role of one's previous knowledge in the learning process. This information is

drawn directly from the results of educational research and cognitive psychology and therefore, reflects the scholarship of integration. The scholarship of application is also an essential component. In order to give effective presentations, students need to apply the teaching principles that have been discussed throughout the course. In summary, the scholarship of discovery, integration, application, and teaching are all part of this course.

Table 1: Description of "Fundamental of College Teaching" Course

Course description

The course, designed for graduate students planning to go into academics and for interested CSM faculty, will focus on:

- Principles of learning and teaching in a college setting.
- Methods to foster and assess higher order thinking.
- Effective design, delivery and assessment of college courses or presentations.

Learning objectives

The course will help students become better able to:

- Describe and apply the principles of learning and teaching in a college setting.
- Design, deliver, and assess a college course
- Apply methods to foster and assess higher order thinking.

Course schedule

Week 1 Introduction. How students learn.
Week 2 Models of intellectual development. Perry, King and Kitchenor. Students take the Kolb Learning Style Inventory, and the Myers-Briggs Type Indicator (MBTI).
Week 3 Learning styles. Interpret the Kolb Learning Style Inventory, and the Myers-Briggs Type Indicator. Implications for teaching and learning.
Week 4 Active learning principles and methods.
Week 5 Cooperative learning principles and methods.
Week 6 Cooperative learning principles and methods, continued. Preparation for classroom observations
Week 7 Discussion of classroom observations.
Week 8 Designing a course or a class presentation.
Week 9 Discussion of planned microteaching topic and final project.
Week 10 Microteaching presentations and critique. Collect journals.
Week 11 Assessment of learning. Creating and scoring exams.
Week 12 Alternate methods of assessment.
Week 13 Microteaching presentations and critique.
Week 14 Roundtable discussion of final projects. Turn in final projects. Turn in journals.

It is expected that students will:

- Keep a journal that records your observations and reflections about teaching and learning. (Questions to be addressed in the journal will be given each week.)
- Complete assigned readings before class. Be prepared to discuss those readings in class. Make entries about the readings in your journal.
- Complete the Kolb Learning Styles Inventory and complete and turn in the Myers Briggs Type Indicator.
- Observe a class session and record your reactions.
- Prepare and deliver two brief presentations to the class of topics in your discipline. (This is called "microteaching".)
- Create a detailed, written plan for a one-semester course. (This is referred to as the "project.")

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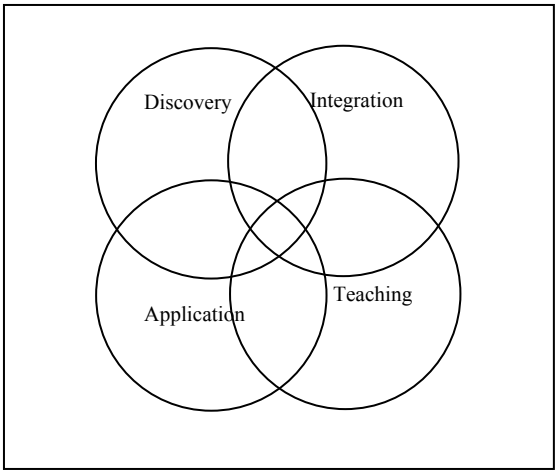
Concluding Remarks

As the discussion above illustrates, the four forms of scholarship that were proposed by Boyer are not mutually exclusive. The scholarship of discover, integration, application and teaching can and do display themselves simultaneously within individual projects. Recognizing the presence of these different forms of scholarship provides a framework in which education and research efforts can be understood. A useful manner in which to conceptualize the four forms of scholarship is as overlapping circles, as is displayed in Figure 1. This model of the four forms of scholarship originally appeared in Streveler, Moskal, Miller, and Pavelich (2001) and is reproduced here with permission. The circles within the model represent the different forms of scholarship and their intersections reflect the natural overlap that exists between them.

Figure 1. The overlap between Boyer's four forms of scholarship (from Streveler, Moskal, Miller, & Pavelich (2001), used with permission.)



The Center for Engineering Education at CSM recognizes and supports the important contributions that each form of scholarship makes to the educational process. In fact, the use of Boyer's four forms of scholarship assists CEE in reaching its goals: 1) to conduct world-class research on the teaching and learning in science and engineering, 2) to use the results of that research to continually improve instruction at the Colorado School of Mines to better support the learning process of our students, and 3) to support the educational needs of science and engineering teachers and learners at the K-12, university, and continuing professional development levels. The first goal requires the scholarship of discover, while the second and third goals require the scholarship of application, integration and teaching. As was illustrated here, some of CEE's sponsored projects reflect all four forms of scholarship. Other projects reflect a subset of the different forms of scholarship. The primary purpose of CEE is to provide a forum in which educational researchers at CSM may pursue scholarship, in a manner that is appropriate to their needs and interests.

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