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Teaching and learning physics: A model for coordinating physics instruction, outreach, and research

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Abstract. This paper describes the development of a new university physics course designed to integrate physics, education, research, and community partnerships. The coordinated system of activities links the new course to local community efforts in pre-college education, university education, university outreach, and research on teaching and learning. As documented both by gains on conceptual surveys and by qualitative analyses of field-notes and audiotapes of class, the course facilitates student learning of physics, as well as student mastery of theories and practices of teaching and learning physics. Simultaneously, the course supports university efforts in community outreach and creates a rich environment for education research. The following narrative describes the motivation, structure, implementation, effectiveness, and potential for extending and sustaining this alternative model for university level science education.

Keywords: physics, education, research, outreach, teaching, service learning

I. Introduction.

The explicit mission of many large-scale research universities includes three core elements: the pursuit of excellence in research, teaching, and community service. However since the mid-twentieth century, many universities have heavily emphasized research without equal commitment to teaching or community service. Efforts directed at supporting high quality teaching (at the university or pre-college level) and partnerships with the communities that house the universities are largely treated as separate, and often non-essential, programs at these institutions of higher education. This paper addresses the question of how such institutions might begin to coordinate these three seemingly disparate elements of the university mission into a single activity system that enhances all three.

The focal point of the coordinated system is a class entitled *Teaching and Learning Physics* offered within the physics department (Finkelstein, 2003). The emphasis of the present work is to describe the structure of the class and the impact of the class on students. Through the use of pre- and post- tests of students' conceptual grasp of the physics content, audio tapes of classes, ethnographic field-notes, course evaluations and student interviews, the class is presented as a case study to demonstrate that such an approach is useful for improving students' grasp of physics and of teaching. At the same time, in addition to documenting the effects that the course has on students, this study examines how well this environment is suited for physics education research, how supporting and surrounding institutions respond, and the potential for sustaining such a pursuit. The discussions of lines of educational research, and the likelihood of sustaining this course, follow the course description and student evaluation.

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The effort to create a coordinated system of teaching, research, and community partnership builds on recent efforts to support student learning in physics, to incorporate education research within departments of physics, and to address a critical shortage of teachers and lack of diversity at the university level. More and more widely, university faculty acknowledge that the traditional lecture-style physics course fails to impart a deep-seated conceptual understanding of course content (Hake, 1998; McDermott and Redish, 1999; Redish, 2003). As a result, in some institutions, a new breed of physics class is evolving -- one that encourages student engagement. Coupled with this recognition, the physics community is beginning to re-assess both the goals of undergraduate courses and what constitutes the discipline more broadly. One outcome of this reassessment is the idea that education research is an integral part of the discipline of physics (APS, 1999). Another outcome is that more departments of physics and schools of education acknowledge the need to better prepare teachers of physics (Schmidt et al. 1999; TIMSS, 1999). Furthermore, in California and elsewhere, a host of political initiatives and educational reforms have challenged the University's ability to meet its charter commitment to serve all of the state's population.[2] At the same time, studies of service learning programs, those which send university students to engage in community-based activities as part of their education, demonstrate significant and improved outcomes for students engaging in these activities (Astin et al. 2000; SLCH 2003). As a result, a significant response from both the legislature and the university system is to support community outreach in an effort to better prepare current and potential students, especially those from traditionally under-represented populations.

This research program addresses these related problems: 1) the improvement of student interest, understanding, and expertise in physics, teaching, and learning; 2) the creation of community-based activities which address the outreach and service interests of the university; 3) the provision of a research site for the study of the teaching and learning processes. The coordinated ensemble, represented by this course, is an opportunity to merge these many agenda. Such an effort follows the work of Cole and others who create rich, theoretically motivated environments that foster student learning and support fundamental research on development and culture (Cole, 1996; Cole, 1998).

II. The Activity.

The course on Teaching and Learning Physics is composed of three elements: a study of physics content, readings about the teaching and learning of physics, and practical experience teaching physics to less educated students. The course is designed for upper-division undergraduate physics majors who have expressed an interest in education. It is described in the course catalog as:

> A course on how people learn and understand key concepts in introductory physics. Readings in physics and cognitive science plus fieldwork teaching and evaluating pre-college students. Useful for students interested in teaching science at any level. Pre-requisites: [introductory level courses in electricity and magnetism]

Each of the three curricular components of the course (physics content, theories of teaching and learning, and practical teaching experience) represents roughly one third of the course. One of the two weekly class sessions focuses predominantly on the study of traditional

[2] The anti-affirmative action debates have received widespread publicity and response both at the state level and at the University of California level. The passing of California Proposition 209 in 1996 was the culmination of many of these debates.

physics content. The other emphasizes readings in physics education and cognitive theories of learning. At least once per week, students engage in the laboratory portion of the course, teaching college and pre-college students.

Each of the course components is designed to complement the others by explicitly providing varied perspectives from which to view physics. Because the course draws upon and addresses questions from different domains (physics, education research, and community outreach), it sits at the interfaces between each of these domains and borrows material and methods from each of these bordering worlds (Star, 1989).

Not only do the course participants benefit from the variety of resources, but also by acting at the interfaces of disciplines, the class provides a mechanism for communication between, and coordination of, these differing domains. For the department of physics and the teacher education program, the course serves both as a catalyst for improving the university students' conceptual understanding and as a common object of discussion and coordination for departments. For physics students, the class acts as an amplifier and reorganizing mechanism for their physics knowledge and as portal from physics into education and teaching. For the outreach program, the course strongly links university efforts in science to community-based education of children. Figure 1 illustrates some of these relations. The figure depicts the three interacting components of the course as the vertices of a triangle. Each of these components necessarily interacts with and in fact co-constructs the others, as will be described in detail below. As a discipline, physics addresses content and the teaching of content. Education concerns itself with the theories and practice of both teaching and learning. Lastly, efforts in community outreach blend the practice of teaching (fieldwork) with content (physics) in community-based settings. Of course, the boundaries of these domains and activities are not fixed, nor are they mutually exclusive.

A program that brings together a study of science content, study of educational and teaching theories, and practical experience teaching science content is remarkably rare, if not unique. Usually, these components are separated. For example, in education schools there are science teaching methods classes, where there is some blending of content and pedagogy. In various science departments, there are an increasing number of classes on cognition and student learning. Also, in various portions of university, there are an increasing number of service-learning or practicum classes where students are guided in teaching experiences. However, each of these approaches differs from design and mission of Teaching and Learning Physics, which strives to blend all three elements.

In this model for a physics course, the students engage in activities that engender both broad-based skills which span these domains (e.g. problem solving, analysis, and meta-cognition) as well as specialized domain-specific knowledge and skills (e.g. physics content, and knowledge of and practice in theories of teaching). In addition, the course is designed to be flexible enough to capitalize on the emergent nature of the activity. That is, because the participants, locales, and even the content are dynamic in nature, the precise form of the activity changes over time. The assertion is not that physics itself is changing (though many may argue about the social construction of the discipline), but rather since the course structure is flexible, it allows the coordinated activities to adapt to local context. The arrangement of the components of this activity system (the vertices in Figure 1) may be thought to be skeletal in nature, and the actual content, interaction, and environment form the "flesh" that is placed upon the structure.

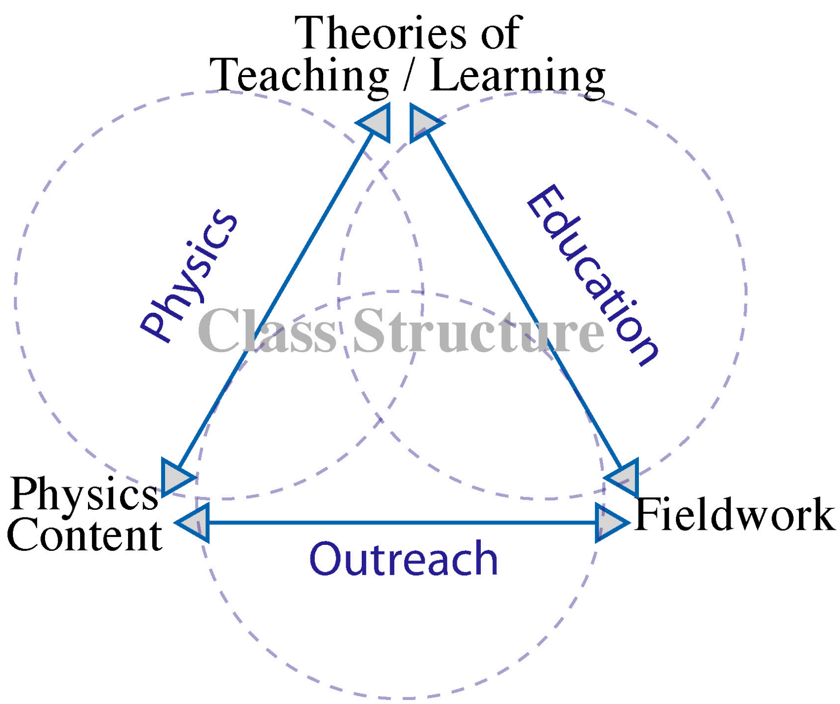

Figure 1. Course structure and disciplinary boundaries.

III. The Organizational Details.

The course is designed for upper division students who have covered at least a minimum level of lower-division coursework in physics. The class meets three hours per week on campus (covering traditional physics content and theories of student learning), and engages students in two to four hours per week of practical experience, teaching in local community centers and schools. Each component of the course focuses on the domain of electricity and magnetism (E&M). As much as possible, each component is integrated with the others; the lines between the activities are purposely blurred. A student reading about theoretical difficulties in understanding the concept of electric field is encouraged to wrestle with his own understanding of the topic. Furthermore, as much as possible, there is a temporal alignment of the activities. The same week that students study electric fields, they read about student difficulties in understanding the concept of fields, and also attempt to teach the concept to others.

The first component of the course covers traditional physics content, approximately two-thirds of an introductory course in E&M (using texts such as Halliday, Resnick and Walker, 1997). While calculus is used in the analysis of problems, mathematics and symbol manipulation are not emphasized. Rather, each topic is introduced from a conceptual viewpoint, and placed within a broader context of other topics in physics. Similarly, the physics segment shifts in focus from symbolic representation and the coverage of text to an active engagement of the students in project-oriented lessons, which foster active construction of models of physics. The class follows a constructivist approach. That is, the course emphasizes learning as a personal and social act where the learner actively builds up understanding using local resources, rather than passively accepting knowledge that is transmitted from the teacher to the student. Most often these lessons focus on the physical construction of material and public presentation.

The added level of emphasis physical construction and public display places the present approach within what Papert calls the constructionist camp (Papert, 1991). These course activities vary from Tutorials (McDermott et al., 2002), to discussion, to group problem solving (Brown and Campione, 1990; Brown, 1992), to teaching and materials development. The lessons are designed to force students to confront traditional difficulties within electricity and magnetism (Posner 1982). The class encourages student learning during class hours, rather than solely after hours. Homework is assigned, but emphasizes the conceptual understanding of content. For example, for traditional textbook-based problems, students reflect on the solution process and critique the problem, in addition to deriving an answer. Other homework assignments include interviewing or teaching novices about advanced concepts in E&M and subsequently writing-up the process and results. Each of these practices is designed to foster development in two domains: mastery of content and improvement of meta-cognitive skills (reflection, regulation, and epistemological development) (Schoenfeld, 1986).

The second course component, readings in physics education research, occurs in a seminar format. Each session begins with brief student presentations followed by discussion. Students support or refute ideas presented in the readings using evidence from the other components of the course. Readings in physics education research fall into several categories: empirical research on learning (McDermott and Shaffer, 1992), theoretical underpinnings of learning physics (diSessa, 1988), and cognitive science approaches to teaching and learning processes more generally (Brown et al., 1989). Students hand in weekly notes with summaries or questions relating to the readings. The notes are commented upon and returned to the students. These informal notes insure that students read the assigned papers, and force some level of reflective analysis.

Student teaching occurs at one of four sites, in and after school hours at the junior and senior high school level. Students are encouraged to develop and teach their own curriculum (within E&M); in each instance, supervisors, both at the university level and at a local level in the partnering junior or senior high school programs, oversee student work. In this fashion, student fieldwork differs from many traditional service-learning models, as the students are guided and are studying both the content and the practice of teaching while engaged in the process itself. Each week students and supervisors write detailed field-notes describing their experiences, curriculum, interactions, and reflections. In addition to using their experiences at the field-sites as a proving ground to test and refine theories of education, students use these sites as resources for research for final projects and papers. Again, the final papers are a mechanism for students to reflect back upon the quarter's activities. Though not a goal made explicit to the students, this teaching experience is designed to help students master physics content as well.

IV. Evaluation and Discussion.

Course evaluation occurs at several levels: at the level of student learning, as a research venue, and as an organizing tool for institutional coordination enabling outreach. The data are presented as a proof-of-concept to demonstrate that this class has the potential to improve student understanding of physics and teaching and learning principles, to serve as a rich venue for research, to provide an avenue for community partnership, and finally, to coordinate these activities into a cohesive whole where the individual components complement one another. The present work predominantly focuses on evaluation at the student level. However, no less significant is the analysis of this system as a research site, or the role that this activity serves in the coordination of various institutions. The data presented are primarily from the first offering of the 10-week (one quarter) course, which enrolled 14 students at a large research university in California.

A. Teaching / Learning -- student expertise in physics

Students' improved capabilities in the domain of physics were of primary interest. It is worthy of note, however, that students generally did not enroll in this course to remediate their understanding of physics. All students in the course had passed one, two or in some cases, three classes in electricity and magnetism. Nonetheless, all students demonstrated improved understanding of the domain. Evaluation of student performance included: pre- and post- test of basic concepts in electricity and magnetism (described in more detail below), audio-recordings of class sessions, student evaluations of the course, and in-class observations. All students who completed the course (N=13) participated in all forms of evaluation with the exception of days when students were absent from class.

The diagnostic test was a mix of thirty-five free-response and multiple choice questions drawn from the Conceptual Survey of Electricity and Magnetism (Hieggelke et al., 2001), the Electrical Circuit Concept Evaluation (Sokoloff et al., 1998), and two original questions.[3] In addition to selecting answers for each question, students provided confidence levels for their answers on a 3-point Likert-like scale (guessing, somewhat sure, certain). Results of the pre- and post- test are shown in Figure 2. The independent axis of the plot lists individual students. The left most student, A, had never formally studied the material and withdrew from the course. The right most student, N, was a fifth year graduate student in physics. A dashed line indicates a division between physics majors and non-majors. The dependent axis plots student performance. The mean pre- and post-test scores are respectively 54% (s= 25%) and 74% (s= 24%). The average of individual student gains is 51% (s=30%; N=13; p<0.001).[4]

Aside from demonstrating improved conceptual understanding of physics, a few points are worthy of note. No student had a complete mastery of the *most basic* concepts at the beginning of the course, despite each student having had some background in physics (and having covered this same material previously). While it is not argued that this class is the most effective mechanism for students to learn concepts of physics, it is clear that it is an effective mechanism for increasing student mastery of basic concepts. Furthermore, upon entering the class, some of the students, even a physics major (Student E), performed at levels roughly equivalent to the un-schooled student, Student A. Generally, those students who had a better grasp of the material upon entering this class made greater improvements than those who were weaker at entry. (The half of the class that performed best on the pre-test made average gains of 66%; whereas, the bottom half of the class made gains of 31%.) Perhaps this is due to the challenge of offering a class to such a diverse range of students.[5] The students backgrounds spanned a range of eight years of exposure to physics. The * next to the student letters on the bar graph indicates female students. On average, there was no difference in performance by gender. However, the two

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[3] The following questions were used from the CSEM: 1-2,6-8,10-11, 15,17-18,20-22,25
The following questions were used from ECCE: 1-5,9-10,12-14,27-32
Additional questions were developed to augment these instruments with free response questions of the same content, and to cover concept of flux. These added questions are similar to the conceptual questions presented in Halliday, Resnick, and Walker (1997). In all cases, these questions address conceptual understanding of introductory material in electricity and magnetism.

[4] The measured gain is similar to the gain Hake (1998) reports : (post-pre)/(100 - pre). However, here, the average of individual gains is reported rather than the gain of the class average. Inverting the order of operations (averaging and measuring gain), shifts the statistical weighting of individual students. The measure of significance is evaluated by means of a single sample t-test of the gain defined above.

[5]. The class was designed for students who had some familiarity with the material at the outset. As a result, the course was better suited for those students who performed better on the pre-test. However, this is not to say the class model could not be used for an introductory level, or for the lower performing students, but rather the class could not equally well address all of the students who spanned a range of 8 years exposure to formal physics.

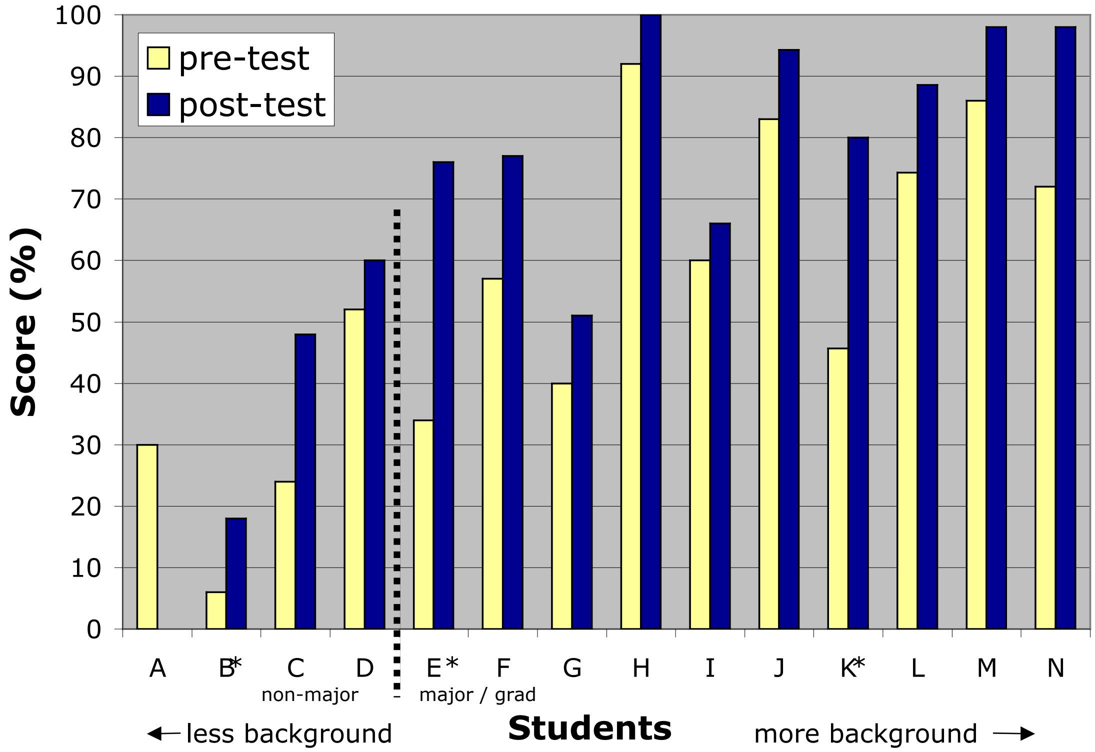

Figure 2: Student pre and post-test scores on conceptual survey of the basic ideas in electricity and magnetism.

Mean pre- and post-test scores are respectively 54% (s= 25%) and 74% (s= 24%). The average of individual student gains is 51% (s=30%; N=13; p<0.001)

greatest improvements in absolute score (post-test less pre-test score) were both women (Students E & K). In this case, there is some suggestion that while there may be some correlation between gender and class performance (Students E & K show 63.5% gains), it is masked by familiarity with the material (by including Student B, the average gain drops to the class mean).

The audiotapes of classes and observational notes written immediately following each class serve as complementary tools for evaluating student understanding in a qualitative fashion. These ethnographic observations are full of examples that corroborate the pre-test data -- students do not begin the course with the expected grasp of material. For example:

> From this discussion it became very clear that [Student C], whom I had asked to step to the board, didn't really understand electric fields all that well (the topic had recently been covered in [this course], and the class pre-req.) ... it was clear that the discussion helped 2 people in the room [Students B and C], was probably useful for [Student I] (whom I often caught guessing).- Day 12

Similarly, class discussions reveal when students may not have a thorough grasp of the material. In a reporting on a research study of students' difficulties with elementary circuits

(McDermott and Shaffer 1992), Student F reveals some of his own difficulties on audiotape, stating:

> _Student F:_ The point is: students tend to reason sequentially and locally rather than holistically. The students don't really see the big picture. ... if you take one light bulb out of the circuit, what would happen? And if it is in parallel or in series is there going to be a change? and the students are not understanding that.
>
> And that's actually where I had ... an interesting thing ... like one of those things we could go over is ummm if it's ...they're doing one of those in series umm ... they're talking about the switch, and Figure 5 [student reads:] "since the total resistance of the circuit would increase, the current through bulb A would decrease, and it would be dimmer." And to me, my gut feeling say that it would become brighter, which is kinda interesting. - Day 9

The use of audiotape and notes helps detail when and why students make conceptual shifts. For example, in a discussion about one of the course readings on the use of analogies for teaching electric circuits (Gentner and Gentner, 1983), a student reflects on the utility of a water reservoir analogy:

> _Student F:_ Can we just talk about…like if you have the uhhh two batteries in series. You get twice the current
>
> _Instructor:_ right
>
> _F:_ Which actually [pause] taught me something. I always thought the batteries in parallel gave you [inaudible]
>
> [discussion of the water analogy and two batteries in series produce twice the current of a single battery for a fixed load]
>
> *F:* okay but see, I thought it was the opposite of that. Because I think I was using the wrong model ...
>
> [Audio tape transcription of class Day 7]

From my notes written immediately following the class:

> Student F made a very interesting revelation, with which Student J also identified: Total lack of conceptual understanding of series and parallel batteries and bulbs. Student F made the comment that he had thought batteries worked differently until he had read the article. Still, throughout the class he and Student J would make little mistakes about relative brightness, voltage etc. When asked to think about it in terms of the article and the analogies presented, [however,] they would get the right answer. It required conscious effort and thought. - Day 7

A comparison of the pre- and post-test responses for students F and J confirms both that the students better understood how elements behave in series and parallel and that the students had greater confidence in their answers. On the series and parallel circuit questions in the conceptual survey, Student F improves 33% from pre-test to post-test (changing from 70% to

80% correct) and his confidence in his answers rises from 1.8 to 1.1 (where 1 is certain and 3 a guess). Student J improves 75% (60% to 90%) with confidence rising from 1.7 to 1.1.

Of course, not all student comprehension increases linearly. These notes and class recordings capture instances when students' understanding regresses and detail the conditions that lead to the retreat in understanding. One particularly interesting case details the regression of Student D who changes models for understanding current flow in a circuit. On the pre-test, the student consistently demonstrates a more expert view. On the post-test, the student consistently uses a more naive model of current consumption. Analysis suggests that this student learned of the more naive model from class discussion, and in particular from another student. Such findings are consistent with others who argue that a more confident, but less expert student may convince a more advanced but less confident student to adopt the more naive view (Hogan and Tudge, 1999). These notes allow for in depth case-studies of students which provide insights into the mechanism behind student achievement, or lack thereof.

Understanding and learning physics is intertwined with students' attitudes. By quarter's end, in an open ended 'comments' section of the course evaluation, students report on their own understanding of the material, and their greater comfort and interest in the subject area:

> "I'm finally enjoying this material [E/M ...] Overall, I've learned (understand finally) so much about E & M and I'm learning about techniques to teach it" - week 5
>
> "I learned a lot about teaching, and even found a new interest in the subject of physics through this course" - week 9
>
> "[The best part of the class was] discovering that I didn't know what I thought I knew about physics" - week 10
>
> "I'm not good at [discussion]. This is really the first class where I have really had to talk about what I think" - week 10

The goal for students in this course was not simply to improve their conceptual understanding of and attitude towards physics, but also their epistemological development (what it means to know physics) and their awareness of their own understanding. Following Hammer's metric of epistemological development in physics (Hammer, 1994), there is some suggestion in these data that students are moving from a belief that physics is a mastery of disjointed formula handed down by authority to a belief that physics is a coherently organized and related set of principles useful for an independently developed understanding of the world. Furthermore, it is suggested in the above quotes (and those reported later in the paper) that students become more aware of their own knowledge. For example, in a discussion about current conservation, Student F reveals:

> I don't know some of these things. I have the same misconceptions that kids and undergraduates that we're reading about. I'm a physics major, and I don't know these things. I can do the advanced stuff (calculations etc...) but not the conceptual side. - Day 9

and field-notes document a similar response by another student:

> Student J detailed his experience of not believing in current conservation. He also identified where this belief arises from.

> Ironically, such thought hasn't been countered by any formal training. He was a little [upset] about this. - Day 9

In terms of Schoenfeld's definition of metacognition, students are self-assessing, which is a necessary precursor to regulating their knowledge of physics (Schoenfeld, 1986).

To summarize briefly, students develop greater expertise in physics broadly conceived. Students demonstrate gains in conceptual mastery, attitudes, beliefs of what constitutes physics, as well as their ability to monitor and potentially modify their own level of understanding of physics.

B. Teaching/Learning -- student expertise in teaching.

The structure of the course was motivated by the belief that such expertise is strongly influenced by students' experiences teaching. In line with this hypothesis, students report improved ability and interest in teaching. In the 'comments' section of course evaluations students report:

> "I got so excited [about teaching]" week 10
>
> "I thought I had a pretty good grasp on how to teach physics, but I've learned enough to revamp my whole style" week 9-
>
> "I loved fieldwork b/c I actually was able to observe the teaching theories involved in class and even put them into practice" week 10
>
> "This [fieldwork] really drove home some of the points made in our discussions and readings" week 10

Students also report that their conceptions of what constitute teaching changed. During the first and last weeks of class, students turned in "statements of teaching," where they were charged with writing a paragraph or two on their approach to teaching and teaching philosophy. They reflect upon what it means to teach: [[6]]

> <u>*Student L, Pre*</u>: ... there seems to be two ways of going about [getting people to learn]. One school of thought is that repetition is how one learns, and the teacher should focus on the most important ideas and go over them repeatedly. The other methods is to saturate the students with information... I have no opinion on which method works better...
>
> <u>*Post:*</u> I believe that teaching is less telling and more leading through interactive experiences. It is important for a teacher to know the subject material and be able to convey it clearly, but it is equally important for a teacher to be able to prompt students into learning experiences through which students learn on their own, and in the process own the knowledge themselves. ...Another important duty of a teacher is to provide an environment for the student that is conducive to learning. This may include ...

[6] Though only three statements are presented here, these responses are representative samples, rather than extra-ordinary student statements.

> providing groups of students for interaction and making sure the students are learning and not just memorizing by getting involved in the learning process.
>
> Student E, Pre: I think that the most important thing to do when teaching physics is to keep the class's attention. This can be done by inspiring students ... making physics ... relevant to their lives, by being humorous or animated ... Make physics class an inviting atmosphere and hold class discussions.
>
> Post: My teaching strategy this quarter in class and at site has focused on creating a solid foundation of physics concepts for the students through hands on activities ... I've made a conscious effort ... not to make previous assumptions about one's knowledge ... I think that group work and project based learning is a more successful way to go than just lecturing
>
> Student H, Post: I have gained invaluable experience in (and learned the main underlying principles of) teaching, both in general, and as it relates to physics. I think this experience has helped me to refine my goals, strategies, and implementation for teaching. ... I also was able to see just how important it is to keep students actively involved with the lesson, participating in through-provoking projects, thinking, answering questions, asking questions, explaining, and discussing ... These activities are where the real learning takes place, not half sleeping through a lecture on the finer points of proving the Schrödinger equation

It should be clear that the class holds a heavily constructivist bent (Papert, 1991), which seems to have seeped its way into the students' consciousness. While may be argued that students were parroting discussions from class rather than shifting epistemological and pedagogical view-points, evidence from students' discussions in class, their field-notes, and final papers, suggests that the students constructed a rich framework of inter-related ideas about teaching and learning. A significant effort was made to ensure that students wrestled with the theoretical underpinnings of their convictions and teaching experiences. Some of these theories and tools for understanding the teaching / learning process begin to cycle through public communication in the course as demonstrated by an increased use of technical language from the course readings in student field-notes. For example, Student H writes of pre-college students' failure to grasp a lesson, "This might be a consequence of the fact that they were not forced to confront many of their pre-conceptions, come upon a conflict, and resolve it." These sentiments parallel Posner's comments on developing a theory of accommodation (Posner, 1982). The field-note continues, "knowledge ... never really became integrated as a system," which, in this context, appears to refer to diSessa's notion of knowledge in pieces (diSessa, 1988) and Reif's discussion of knowledge structures (Reif, 1986). Students adopt strategies from the readings and reflect on their own success and failure to implement these strategies in the teaching environment.

Based on observations, students' field-notes, and student final projects, there is strong indication that students became better teachers. Students were found to implement and evaluate practices discussed in class, to research other methods of teaching, and to appropriate these for use in their own teaching environments. Students constantly evaluated their own practices (and each other's). For example, in Student F's field-notes, he reflects on the effectiveness of two approaches to teaching:

> [The high school] students seemed to respond fairly well to the light bulb/ resistor box experiment, but seemed bored when explained to them by theory on the white board. After the explanation, many students were not able to guess [correctly] about the change in brightness of the bulb as the resistance in the series with the bulbs changed. Only after they were able to play with this themselves, were the students able to make theories. - Day 13

Approximately half of the final student projects were directed at assessing pre-college student performance and how performance correlated with such variables as teaching style, learning environment, representational form of the material, or gender. These studies served to confirm or refute others' theories of student learning, and to evaluate which strategies work best for the University students in their working environments. For example, in a study of the effectiveness of representational forms (white-board versus worksheets), Student L confirms the benefits of active-engagement and begins to examine why this works in his classrooms:

> To see why these two environments [high school and college] yielded such opposite results, one must contrast the situations of the students involved. One can expect that when students learn from a lecture format lesson, they will not be able to apply the concepts as abstractly as when they were involved in the learning. Not only will the students be merely watching and not participating, but also it is quite likely that hey will not keep interest in the presentation … At the [college] session, the students were actively learning, discussing and sharing. The [high school students] were instructed to draw diagrams, whereas the U[niveristy] students were using diagrams as tools to reach a goal – finding a solution to a problem. - Final paper, Student L

Student L uses the opportunity of teaching and of conducting a study of his students' learning to develop his own theories of and strategies for teaching.

In summary, because of the coordinated activities of the course, students demonstrate a greater grasp of both physics and of teaching, and student improvement in each of these areas is broad and multi-faceted. Students demonstrate an improved grasp of content and application of content.

C. Potential for Research.

This course provides a valuable research venue for making insights into the process of learning physics. While a host of such opportunities exist, the present focus emphasizes undergraduate learning. Data from student work, interviews, audio taped classes, and field-notes suggest how the course affords insight into the importance of context in the learning process. The sections above suggest several features of the context and content of this program -- the interplay between the study of teaching / learning and the re-examination of physics--that enhance student learning.

First, it appears that teaching a topic forces an added level of reflection both upon the content and about an individual's own mastery of the subject. In support of this work, data from the class are being analyzed to observe the effects of teaching. Preliminary analyses of student performance indicate that students are more likely to master a subject conceptually if they teach the subject than if they cover textbook homework problems for the same amount of time. However, more data and analysis are required to make any definitive judgment.

A related line of research explores a critical link between student, content mastery and local context. Following the work of Cole (1996, 1998) current efforts address the relevance of researching student learning in context. In studying these environments and their implications for student learning, Cole argues that assessment of cognitive ability is contextually dependent -- that is, the further removed an experiment or study is from the domain of use/ application, the less applicable the result is to that domain. This same notion has been reported in a somewhat different form in physics. Studies, such as those using the Force Concept Inventory (FCI), report that while students may perform well in a traditional physics course, a course in which they have managed to master formulae and various mathematical procedures, the students miss the broader setting and conceptual basis for the discipline of physics (Redish, 2003). The first step in this exploration has been to develop a model of how context may be brought into the present research discussions on student learning of physics content (Finkelstein 2001; 2004).

Lastly, a rich area for investigation is the effect such a course has on students crossing disciplinary boundaries, and in particular, whether education can become a legitimate pursuit for physicists. There is evidence that this course helped students cross disciplinary boundaries. Of the six undergraduate physics majors in this study, four enrolled in teacher education programs. Three of these four enrolled in the university's teacher education program (tripling the annual enrollment of physics majors). A fifth student took a year abroad to teach and ultimately returned to enroll in an education program. Of the four graduate students enrolled, one took a post to in the physics department to direct the undergraduate laboratories. Another two were active participants in the American Association of Physics Teachers-sponsored graduate training program, Preparing Future Physics Faculty (PFPF), offered by the department. A more in-depth longitudinal study would be required to observe the longer term and broader impacts of the course. However, these preliminary signs indicate that by presenting the opportunity to explore and seriously consider education as a pursuit within the physics department, students begin to do just that.

D. Institutional response --- Can this activity survive?

The institutional response to this new activity system has not been a simple or monolithic process, and is worthy of a detailed research study in its own right; however, the program has initially met with some success. In Seymour Sarason's framework this coordinated set of activities constitutes a new *setting*, or a new and sustained relationship between individuals (Sarason 1989; 1997). Sarason contends that program success or failure depend critically upon two factors: the initial structure of the program and the adaptation of that structure to local conditions.

After extensive setup (and lobbying of the department and other institutional entities), the course on Teaching and Learning Physics was incorporated into the institutional structure. The Department of Physics has adopted the course as an upper division restricted elective in the sequence of classes required for a bachelor's degree. The Teacher Education Program offers the class as part of its certification program. Additionally, this class is the first course to be cross-listed between the physics department and the Teacher Education Program. In establishing and maintaining this course, an inter-disciplinary team has gathered to critique and help shape the course. Following the establishment of the course, the Director of Teacher Education Preparation and the Vice-Chair of Physics engaged in collaborative discussions surrounding the development of a new undergraduate physics and education major. While the new major was not constructed, the course continues to the present, some several years later. As Sarason suggests, the creation of a new setting, one that often begins with multidisciplinary work, necessarily affects the local, disciplinary, and interdisciplinary cultures in which the new setting is created (Sarason 1989).

However, as Sarason goes further noting that these systems all-too-often depend upon a single individual and hence may not be able to adapt when that individual leaves (Sarason 1997). The course on Teaching and Learning Physics was offered by the author three times before leaving the institution. Each of the first three sessions was offered voluntarily (that is, with funding support coming from a National Science Foundation Fellowship rather than the department). With an eye to handing the course over, a second faculty member participated in the course the second time it was offered. Currently, course is under the supervision of the new instructor and been offered twice, with the support of the department. There is some indication that given the success of the course, it may continue; however, the difficulty of relying upon a single individual's efforts and advocacy remains-- When the current instructor retires or moves on, it is not clear that the course will continue.

Beyond the local or micro-level, the course is part of a larger activity system of community partnership. As described, fieldwork is an integral component of the course, and as such, has required the development and strengthening of ties with community partners. The community agencies which host student-teachers from the university course, such as local schools and Boys and Girls Clubs, have indicated great interest in the continuation of collaborative efforts. The community partners greatly value the added human resources of student-experts who participate in local activities, and in several cases used these added resources to develop new educational programs. Without the involvement of the undergraduates in the outreach process, two of the four community-based programs would not have operated. Meanwhile the community-based programs serve as necessary resources for the university students and researchers who use these environments as laboratories for studying pre-college student learning. In this way, it is not simply a matter of the university delivering outreach and programming, but rather a collaborative arrangement whereby both partners develop and benefit from the interaction. Community-university partnership programs, using this model, continue to expand both in size and scope (into more schools and at more educational levels).

An unexpected outcome of offering the course was newfound collaboration with one of the local two-year colleges. The chair of the local community college physics department participated in the class on Teaching and Learning Physics the first time it was offered. Through the course and following years, members from both the community college system and the university system explored mechanisms to increase transfer rates from the two-year college into the university, and in particular, into physics. One project that stemmed from these discussions was the augmentation of the graduate training program, Preparing Future Physics Faculty (PFPF), with the opportunity for graduate students to teach students at the community college. Using materials from the course on Teaching and Learning Physics, graduate students developed and offered a new course to community college students. The first two offerings of the course were successful at providing graduate students valuable and authentic teaching experiences, exposing students at the two year college to physics and the university culture, and increasing the transfer of students from the community college to the university. Once again, however, whether these ties will be sustained with the absence of key individuals is unclear. One of the graduates of the PFPF program continues talks with the community college; however, the joint program has not been offered since the author left the university.

V. Conclusions.

The presented model for coordinating physics education, research, and community partnerships may be adopted more broadly within the (science) education community by substituting different content. There is nothing particular to physics, nor undergraduates in this model. The domain of examination could equally well have been Newtonian mechanics, or physical chemistry. The outcomes would be similar: increased student interest and ability in the science domain, increased attention to and interest in teaching and education, and development of community partnerships. Furthermore, the activity system provides a rich opportunity for science education research that is tightly coupled with and informed by educational reforms. As institutions of higher education begin to develop programs of discipline-based education research *within* the sciences (science departments, and in particular physics departments are hiring an increasing number of faculty into new lines physics education research / reform), this type of activity system provides an avenue to leverage local interest in reform, research, and community partnership. Because such a system addresses the multiple motives of physics, education, and outreach, the hope is that each domain would support the activity and would develop an authentic interest in sustaining a coordinated program. Of course, such change is local and depends simultaneously upon fertile ground (local or bottom-up support) and healthy conditions for growth (top-down support).

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Students' Evaluation of Tertiary Educational Goals: The Impact of Lecturer and Student Characteristics

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Abstract: This study is concerned with how tertiary students evaluate educational goals within their degree programs. Crooks' (1988) classification of educational practices in terms of short-term and medium-term consequences is used. This study assesses the viability of his classificatory system within a university student sample. The current study extends previous research by considering both lecturer characteristics (e.g., lecturer supportiveness, teaching quality, approachability of lecturing staff and availability of lecturing staff) and student characteristics (e.g., age and student's year level) which may predict how educational practices are evaluated. Evaluation data are provided by 164 volunteer students (31.5% males and 68.5% females). The principal component analysis was able to establish a list of short-term and medium-term goals appropriate for a university student sample. Lecturer supportiveness predicts short-term goals while teaching quality and student's year level predicted medium-term goals.

I. Introduction.

Student evaluation of teaching effectiveness (SETE) has been used in Australian universities for some time now as part of the quality assurance process. Student evaluation data are used by individual departments in making personnel decisions, in the allocation of teaching resources, as well as in decisions about whether or not to offer a subject. Student ratings influence faculty decisions regarding promotion and tenure of lecturing staff, as well as in the award of teaching merit grants. Students also use evaluation data in selection of degree courses and specific subjects. Such use of student rating data has been termed summative evaluation, in contrast to the use of teaching effectiveness ratings by individual instructors for the purpose of improving teaching, otherwise referred to as formative evaluation (Theall & Franklin, 2001).

Ratings of teaching effectiveness are typically made on a teacher rating form (TRF), with considerable similarity in the types of questions asked across tertiary institutions in the United States, Australia and the United Kingdom. These questions generally ask about the lecturer's knowledge of the subject area, the clarity of the lecturer's explanations, willingness to answer questions, fairness in grading assessment, and punctuality. Instructors can also choose to include in their subject evaluations, items from an additional list of questions. These questions evaluate features specific to the discipline e.g. laboratory sessions, field trips; the use of technology such as computer-generated slide shows, the Internet, and electronic mail to communicate with students; and in the case of cross-campus teaching, questions might evaluate the learning experience via video-lecturing. Evaluations of teaching effectiveness are important because they

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give insight into the quality of the learning experience for the student, and subsequently how degree programs are evaluated in terms of the attainment of their educational goals.

The last 30 years have seen a proliferation of research studies addressing the validity of student evaluations of teaching effectiveness. Concerns about validity have centred on a number of issues: students not being qualified to assess the lecturer's competence, that ratings may reflect popularity, the possibility of lecturer ratings being influenced by grades received, that students rate highly those lecturers who are lenient and from whom they learn the least, and that gender and other situational variables (such as class size, year level and required versus elective subjects) may influence ratings
(Marsh, 1984; Ory, 2001; Theall & Franklin, 2001). The underlying rationale of research addressing the validity of student evaluations of teaching effectiveness, is that if student ratings are valid, they should predict criteria of effective teaching such as performance on examinations and achievement in the subject. In a meta-analysis by Cohen (1981) of 41 studies across 68 courses, the correlation between student achievement and their ratings of the lecturer was 0.43, indicating that students rate highly those lecturers from whom they learn the most. More recent research indicates that student expectations about their grade in a subject (Greenswald & Gillmore, 1997), and actual grades received (D'Apollonia, Lou & Abrami, 1998) affect their evaluation of the lecturer. The question of rating validity has largely been addressed in relation to evaluations of teaching effectiveness. The literature is scant on whether these same variables (e.g. grading, class size, year level) and indeed others, affect how the educational goals of degree programs are evaluated.

Less attention has been given to instructor characteristics which may influence ratings of teaching effectiveness. Williams and Ceci (1997) found a difference of 2 scale- points on student ratings when the instructor varied presentation style so as to be more enthusiastic. Williams (2001) reported that student evaluations of instructional style were strongly correlated with overall evaluations of the course. Other research (Shevlin, Banyard, Davies & Griffiths, 2000) has found that teacher effectiveness ratings are accounted for by perceptions of the lecturer's personality or 'charisma,' lecturer ability and module attributes. The quality of the learning experience depends on more than the actual instruction received. Instructors can influence students in a number of ways such as in motivating them to read further on a topic, to reflect critically on issues, and in the application of ideas to novel situations. It would be expected that instructor characteristics such as warmth, attitude and supportiveness would influence perceptions of the learning experience, and ultimately how the degree program is evaluated.

Given that the learning experience involves student and instructor in a dynamic interaction, it is surprising that little research has been focussed on the interactive influence of student and instructor characteristics on how degree programs are evaluated. From earlier research, we know that student ratings are higher for elective rather than required courses (Marsh, 1984) and in higher level courses rather than in lower level courses (Feldman, 1978) indicating that the student's year level should be taken into consideration. Given that a large proportion of university students are mature aged involved in study for the first time or changing career paths, age of the student should be considered in student evaluations. In a study by Stringer and Irwing (1998) which used structural modelling to examine the effects of course, student and instructor characteristics on students' evaluations of teaching, it was found that teaching quality exerted a direct influence on evaluations of course integration, and had an indirect influence on stimulation/learning and overall evaluations. Interestingly, student characteristics (such as motivation, study habits and prior knowledge) and course characteristics explained a substantial amount of the variance in overall evaluations independent of teaching quality.

With minor exceptions (Stringer & Irwing, 1998) most of the research into student evaluations of teaching effectiveness has centred on subjects or modules rather than degree programs/courses. In addition, where teaching has been evaluated in specific modules, TRFs of the individual universities have been used. While these rating forms evaluate a number of worthwhile attributes of the module and the teaching quality, they tend to be global rather than specific in their evaluation, and often do not provide any detailed information on whether the educational goals and objectives of the degree program were satisfied. Crooks (1988) provides a list of consequences associated with student classroom evaluation practices which might be relevant to the educational experience of university students. These educational consequences, referred to as goals by McInerney and McInerney (1994), are classified in terms of duration of impact (short-term, medium and long-term) on learning strategies, and skill development. In this study, we sought to obtain more detailed information on university students' evaluation of the educational goals of their degree programs, rather than focussing on specific modules. Of interest also was whether student and lecturer characteristics affect how degree programs are evaluated.

Accordingly, the aims of the research were to:

1) study how students evaluate the educational goals within their degree programs
2) examine the effect of lecturer characteristics (such as supportiveness, teaching quality, approachability, and availability) and student characteristics (age and year level) on student evaluations of educational practices.

II. Method.

A. Subjects.

The students (N=164) were a convenience sample of volunteers recruited from several degree programs within the university setting. No course instructors solicited student participation in this study. Whenever the results do not add up to 164 it is because the missing values have been omitted. The students were 31.5% (n = 51) males and 68.5% (n = 111) females aged between 18 and 55 years (M = 29.0, SD = 9.6), enrolled in a cross-section of undergraduate courses. This gender bias reflects the gender-mix within the university student population. More specifically the students can be categorized as follows with regards to the courses they were enrolled in: Bachelors of Social Sciences and Arts (n = 64, 41.0%), Bachelor of Psychology (n = 43, 27.6%), Bachelor of Education (n = 32, 20.5%), Bachelor of Science (n = 8, 5.1%) and Bachelors of Management, Law and Tourism (n = 9, 5.8%). Approximately one third of the sample came from each of the year levels of the students' degree programs. The student sample was evenly split in terms of students who lived alone and those who lived with a partner. Only 22.1% (n = 36) of the students were not employed, while pursuing their studies, with the remaining 77.9% (n = 128) being involved in some type of work for pay. The majority of students (n = 107, 70.4%) were residing in rental accommodation and 29.6% (n = 45) either owned their own home or were paying it off. About half of the student respondents (n = 76, 46.9%) lived ten kilometres or less from the campus, 49.4% (n = 80) lived between ten and 50 kilometres from the university and the remaining 3.7% (n = 6) of the students lived 50 or more kilometres away from the university.

B. Questionnaire.

After obtaining ethical clearance a questionnaire specifically designed for this study was used to collect the anonymous data from a voluntary student sample enrolled in different degree programs and from different year levels. The questionnaire consisted of items assessing the educational goals of the student's course of study, lecturer characteristics, and student characteristics.

Table 1: Percentage of students responding that the educational goals have been met in their university course of study.

Item	N	%
Helping students feel a sense of accomplishment.	117	71.3
Checking that students have adequate prerequisite skills and knowledge to effectively learn the material to be covered.	88	54.3
Communicating and reinforcing the instructor's or the curriculum's broad goals for students, including the desired standards of performance.	107	65.6
Focusing attention on important aspects of the subject.	128	78.5
Influencing students' choice of (and development of) learning strategies and study patterns.	76	46.6
Describing or certifying students' achievement in the course, thus influencing their future activities.	86	53.1
Reactivating or consolidating prerequisite skills or knowledge prior to introducing new material.	92	65.1
Encouraging active learning strategies.	92	56.1
Helping students to monitor their own progress and develop skills of self-evaluation.	74	45.1
Influencing students' motivation to study the subject and their perceptions of their capabilities in the subject.	89	54.3
Giving students opportunities to practise skills and consolidate learning.	107	65.2
Guiding the choice of further instructional or learning activities to increase mastery.	84	51.2
Providing knowledge of results and corrective feedback.	117	71.3

The educational goals presented here come from Crooks' (1988) review of the impact of classroom evaluation practices on students. These practices are classified in terms of eight short-term consequences and five medium-term consequences that can be used as a checklist of the qualities of good educational practices (McInerney & McInerney, 1994). The percentage of students reporting that the educational goals have been met in their chosen university course of study is presented in Table 1. An example of a short-term goal is: "guiding the choice of further instructional or learning activities to increase mastery". A medium-term goal from the list is "influencing students' motivation to study the subject and their perceptions of their capabilities in the subject". The goal that was seen as being met by most of the students was that of focusing attention on important aspects of the subject (n = 128, 78.5%). The goal that was least seen as having been met in their course of study was that of helping students to monitor their own progress and develop skills of self-evaluation (n = 74, 45.1%). The reliability coefficient (Cronbach's Alpha) for the short-term goals was 0.60, and for the medium-term goals was 0.58.

The items assessing lecturer characteristics focused on lecturer supportiveness, teaching quality, approachability and availability of the lecturing staff. The student characteristics included age, gender, course and year level information, marital status, employment status, whether they were or were not living in rental accommodation and the distance they resided from the university.

III. Results.

A principal components analysis was used to see whether similar clusters of educational goals (Crooks, 1988; McInerney & McInerney, 1994) could be identified within a university student sample. The analyses for this study were performed using SPSS 11 for Windows. Bartlett's test of sphericity (276.57) is large and the associated significance level is small (p = .000), consequently it appears unlikely that the population correlation matrix is an identity, that is, all diagonal terms are one and all off-diagonal terms are zero. The Kaiser-Meyer-Olkin measure of sampling adequacy found to be in the middling range (0.67) is an index for comparing the magnitudes of the observed correlation coefficients to the magnitude of the partial correlation coefficients. Both these measures suggest that the use of the factor model is appropriate. Table 2 presents the factor structure obtained.

The principal components factor analysis using varimax rotation revealed two factors which have been labelled 'short-term goals' and medium-term goals'. A factor loading exceeding 0.30 was used to determine high loading items. Two items that were originally medium-term goals in fact were found to load on the current short-term goals factor (ie., communicating and reinforcing the instructor's or the curriculum's broad goals for students, including the desired standards of performance; and checking that students have adequate prerequisite skills and knowledge to effectively learn the material to be covered). With regards to the second factor three items that originally loaded on the short-term goals factor were found to load on the medium-term goal factor (ie., helping students feel a sense of accomplishment; encouraging active learning strategies and focusing attention on important aspects of the subject). Using the scree criteria the eigenvalues for the factors were 2.85 and 1.41 respectively. Factor scores were computed for each of the two factors where the two factor scores take into account the contribution of each scale item to each factor. These were then used as dependent variables in the regression analyses.

Standard multiple regressions were used to analyse the data. The assumptions of sample size, multicollinearity and singularity, outliers, normality, linearity, homoscedasticity and independence of residuals were not violated in these analyses. Educational goals were then regressed on predictor variables of lecturer supportiveness, teaching quality, approachability of lecturing staff, availability of lecturing staff, age, gender and year level. Table 3 presents the significant regression results for short-term goals. Of all the variables considered, lecturer supportiveness (that is, the greater the supportiveness) made the largest unique and significant contribution (Beta = 0.23, p =.007) in explaining short-term goals. The variables considered explain eight percent of the variance in short-term goals.

Table 2: Varimax rotated factor matrix for the evaluation goals (N = 157).

Item	Factor Loadings 1	2	Communality h^2
Giving students opportunities to practise skills and consolidate learning	**.747**	.037	.560
Communicating and reinforcing the instructor's or the curriculum's broad goals for students, including the desired standards of performance	**.702**	.031	.494
Providing knowledge of results and corrective feedback	**.594**	.046	.355
Checking that students have adequate prerequisite skills and knowledge to effectively learn the material to be covered	**.431**	.281	.265
Guiding the choice of further instructional or learning activities to increase mastery	**.430**	.239	.242
Reactivating or consolidating prerequisite skills or knowledge prior to introducing new material	**.390**	-.010	.152
Focusing attention on important aspects of the subject	**.314**	.288	.182
Helping students to monitor their own progress and develop skills of self-evaluation	**.282**	.242	.138
Influencing students' choice of (and development of) learning strategies and study patterns	.080	**.746**	.563
Helping students feel a sense of accomplishment	.015	**.574**	.330
Influencing students' motivation to study the subject and their perceptions of their capabilities in the subject	.102	**.560**	.324
Encouraging active learning strategies	.246	**.550**	.363
Describing or certifying students' achievement in the course, thus influencing their future activities.	.003	**.546**	.298
Eigenvalues	2.853	1.413	4.266
% Common Variation	66.88	33.12	100.00
% Total Variation	21.95	10.87	32.82

Table 3: Regression of short-term goals on lecturer and student characteristics (N=153).

Predictor		Beta	SE	t	p
Lecturer Supportiveness		0.23	0.12	2.76	0.007
Teaching Quality		0.07	0.20	0.90	0.37
Approachability of lecturing staff		0.05	0.19	0.51	0.61
Availability of lecturing staff		0.01	0.18	0.16	0.87
Age		-0.14	0.01	-1.64	0.10
Year level		0.12	0.09	1.50	0.13
Intercept	-1.03				
R^2	0.08				
Adjusted R^2	0.04				
F = 2.10, df = 6,152 p = .05					

Table 4 presents the significant results for the medium-term goals. Year level (Beta = -0.21, p = .01) and teaching quality (Beta = 0.21, p =.01) best predicted medium-term goals. These two significant variables were equal in their contribution in explaining the medium-term goals. The variables were found to account for 11 percent of the variance in this model.

Table 4: Regression of medium-term goals on lecturer and student characteristics (N=152).

Predictor		Beta	SE	t	p
Lecturer Supportiveness		0.13	0.11	1.58	0.11
Teaching Quality		0.21	0.20	2.53	0.01
Approachability of lecturing staff		0.02	0.18	0.20	0.84
Availability of lecturing staff		0.04	0.17	0.46	0.65
Age		-0.02	0.01	-0.21	0.84
Year level		-0.21	0.09	-2.58	0.01
Intercept	-0.20				
R^2	0.11				
Adjusted R^2	0.08				
F = 3.12, df = 6,152 p = .007					

IV. Discussion.

The focus of this study was on how students evaluate entire degree programs rather than with evaluation of individual subjects/modules and individual instructors, and whether evaluations of the degree program are influenced by lecturer and student characteristics. While perceptions of subjects taken, and evaluations of the teaching quality within these subjects would to some extent influence overall ratings of the quality of the degree, the approach taken allowed for a more in-depth evaluation of whether students perceived the degree to have satisfied basic educational goals such as consolidating prerequisite skills, facilitating motivation to learn, and encouraging active learning strategies. These goals were adapted from Crooks' (1988) list of educational consequences associated with student classroom evaluation practices. As these practices were considered relevant to the educational experiences of university students, the data were factor analysed to assess the viability of using Crooks' classificatory system in a tertiary setting. Factor analysis confirmed Crooks' classification of short-term and medium-term influences, with only minor differences in the items loading on each factor.

While most universities routinely collect data on student evaluations of teaching effectiveness, this is often done at the subject and individual instructor level for either formative or summative purposes of evaluation. It is at the discretion of individual departments to have final year students evaluate their degree programs. This study is advocating that Staff Development units work on developing a standardised form to facilitate the monitoring of educational goals/practices of degree programs within university faculties. While the present study found Crook's (1988) classification to be a useful basis of such evaluation, it could be supplemented with discipline-specific questions relating to student placements and other applied learning approaches. As a means of compiling formative evaluative data, student evaluations of the degree program could be compared with evaluations of alumni working in the profession. If there is a deficit in skill development in a specific area, as identified by recent graduates, this information can be used in decisions about subject offerings and in staff selection decisions.

In this research we were interested in assessing the influence of lecturer characteristics and student characteristics on how degree programs were evaluated. Evaluation of short-term goals such as checking prerequisite skills, providing opportunities to consolidate learning, providing corrective feedback, and developing skills of self-evaluation were influenced by lecturer supportiveness. Students who perceived these short-term goals to have been adequately met in their degree program were more likely to also perceive lecturing staff to be supportive. While previous research has examined the influence of instructor characteristics on student ratings, the emphasis has been on stylistic and presentation variables rather than on more subtle person characteristics (Williams & Ceci, 1997). Lecturer personality was reported by Shevlin et al. (2000) to account for effectiveness ratings, as much as ability. The present finding would seem to substantiate the need to acknowledge the importance of person variables in the interactive learning experience.

In relation to the evaluation of medium-term educational goals of degree programs, it seems that other instructor characteristics relating to knowledge base and teaching quality are also important. Such medium-term goals include influencing choice of learning strategies and study patterns, motivating students, encouraging active learning strategies and focusing attention on important aspects of a subject. In Stringer and Irwing's (1998) study, teaching quality was found to have a direct effect on student's evaluation of course integration, while indirectly influencing stimulation/learning. There are therefore consistencies across the two studies even though the level of analysis is different – degree program compared to individual subjects.

In regard to student characteristics, year level was negatively associated with evaluations of the extent to which medium-term goals had been met by the degree. Students at higher levels tended to be more critical than lower-level students possibly because by the final year of their course, students are more knowledgeable of a discipline and have higher expectations regarding training. Likewise, Sailor, Worthen and Shin (1997) found that upper-level students were more critical in their student evaluations. These findings are contrary to previous research by Feldman (1978) where higher ratings are given by higher level students. The difference in findings may be due to evaluations of subjects/individual instructors in the Feldman study as opposed to evaluation of a degree course in the present study.

The explanatory model in the present study did not account for much of the variance in student evaluations of their degree programs. A number of interpretations could be offered for this finding. Firstly, student evaluations may actually be robust, such that they vary little across student characteristics such as age or year level. Moreover, lecturer characteristics such as perceived competence, approachability and supportiveness may exert little influence in how tertiary educational goals are evaluated. Secondly, the explanatory variables may have been correctly specified for a different dependent variable. That is, the current study used Crook's short-term and medium-term educational goals to evaluate degree programs. Future research may wish to replicate the present findings using a different set of evaluative criteria to assess degree programs. Lastly, perhaps other variables may need to be considered in relation to tertiary educational goals. Some such variables may be whether or not the university is a regional one, with limited student resources, the quality/quantity of library resources with access to electronic databases and electronic journals, the use of internet teaching and video-lecturing limiting access to lecturing staff, and the availability of student placement opportunities for regional universities.

Student learning in university settings is multifaceted. Students may learn through instrinsically motivated reading and exploration of ideas, in classroom group situations through the sharing of ideas, and through lecturer imparted knowledge. The learning process can be considered to be dynamic. Even in typical lecture settings, students are not inactive recipients of knowledge. They actively work on the information, ask questions, debate and discuss aspects of the learnt material. As such evaluation of the learning experience should also take into account student factors and situational factors (setting, module characteristics), in addition to instructor characteristics. Where such variables are found to influence student evaluation ratings, this does not invalidate the evaluation process but rather gives a more realistic account of interactive influences in the dynamic of teaching.

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"The Map is not the Territory": Stories from the Classroom

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Gregory Bateson's (1988) enigmatic phrase, "The map is not the territory," carries a provocative message for scholarship on teaching and learning. I explore the implications of Bateson's phrase by way of reflecting on Bateson within the context of my own classroom story, which was based on teaching a literacy course to pre-service teachers. Teaching and learning comprise the "territory" while the curriculum is the "map." The teacher-educator helps the student teacher construct bridges from one realm to the other by way of a process in which both teacher-educator and student teacher are participants. Learning is reconceptualized as about learning about the learning process itself rather than being focused on producing a map.

I. Pleroma and Creatura.

Gregory Bateson was deeply interested in teaching and learning and often used classroom stories to clarify his meaning. For example, to a group of psychiatry students, he posed the following exam question: "Define 'sacrament' and 'entropy'" (Bateson, 1988, p. 6). These terms must have seemed remote to his students, and the connection between the two terms even more elusive. However, Bateson often challenged his students to look for relationships between things that appeared to be dissimilar and removed from the students' experiences. He brought a crab into a class of art students and challenged them to prove that the inert object was a living thing. Bateson tried to impress upon his students that "the map is not the territory." While this phrase of Bateson's sounds enigmatic, it lies at the centre of his teaching practice: "in the Pleroma there are no maps, no names, no classes, and no members of classes. The map is not the territory. The name is not the thing named" (Bateson & Bateson, 1987, p. 21). Bateson's pedagogical approach was to have students confront the map-like boundaries used to compartmentalize and sunder things. Bateson's accounts of his students' initial bafflement in such situations has reminded me of my own stories from the classroom, and of how student teachers resist notions of curricula that sound foreign against the background of their schooling or seem inconsistent with their conceptions of how practicing teachers teach.

> *"The map is not the territory." These words rushed through my brain.*
> *"How can doing this assignment prepare me for developing units in my practicum?" the student teacher demanded. Pause. "I took this course because I was told," and she emphasized the word "told", alluding to the higher power that supported her bone of contention: "I was told that I would be working on an assignment that I could directly use in the second week of my practicum." She paused again for dramatic effect. "That was what I was told." She munched on her food and waited for my response.*
> *Her reaction was provoked in response to a map, a course outline, a specific geographical point on this " map": my choice of assignment. Are we quibbling*

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over maps, I asked myself, or is it just a semantic difference, namely, the word, "unit"? The name is not the thing named.
"Well, you're right that the assignment focuses on using a literacy strategy within instructional scaffolding. It is not intended to be a unit but it will provide you with strategies that students can use to be autonomous learners. That is our purpose. To encourage students to be autonomous learners rather than dependant on the teacher." As a conciliatory gesture, I inserted, "You could expand it into something like a unit. People have done that before. Combined strategies."
"How many days?"
"Pardon?"
"How many days will this lesson last?"
Ah. A light goes off inside and the waves start to wash over me. I've been here at the university for so long that a part of me has forgotten what it was like to be there, a beginning teacher, with the insecurity of not being able to imagine what teaching looks, feels and tastes like, and feeling pressure from the powers-that-be to produce something that conforms to a pre-set plan. In a unit, you begin by specifying a theme. You specify your objectives, which materials you'll need, how the lesson will proceed from introduction to middle to closure. The lesson follows a precise rhythm that can be clocked. You specify how many days the unit will last and how many minutes each lesson, and each part of the lesson, will endure. My teacherly frames have shifted so far that, immured in my new location, I've forgotten that such frames exist. I'm in a different place from where she is. But I too am in a new teaching situation: a novice university instructor. So, touché.
Not all of these thoughts come right away. It is on the familiar walk up the hill towards home that it hits me and, as Bateson might say, information comes through pleroma in the form of difference. An understanding of the difference between where I am at and where the student teachers are (or some of them are; I don't want to overgeneralize). My answer, as I sit down at the computer that night, a little weary but determined, is to bridge between paradigms.

Bateson (1972) tells the story of how Jung complained that his house was full of noisy ghosts bothering him and his family. Bateson thought that Jung was experiencing "an epistemological crisis" because when Jung sat down to write, all the ghosts disappeared; he dated "all of his later insight" to these writings (p. 455). One of Jung's insights from this period, records Bateson, was that there are two worlds, "pleroma" and "creatura" (p. 456). In the pleroma, "events are caused by forces and impacts" (p. 456). Here, "no distinctions" obtain among things (p. 456). Differences are what speak to human beings across pleroma. Synonymous words for "difference" include "information" (Bateson, 1988, p. 72) or "news" (Bateson, 1972, p. 454; Bateson & Bateson, 1987, pp. 14, 17). Information comes to us from the pleroma. The map is not the territory. Pleroma is not creatura. The "territory never gets in at all" (Bateson, 1972, p. 454). Only "difference" does.

Bateson emphasizes how, as a society, we tend to mistake the map for the territory. A paradigm shift needs to take place, not in order that we can move into pleroma from creatura, says Bateson (1988), but so that we can achieve a higher level of creatura. To understand the significance of the shift within teaching and learning that Bateson is proposing, we need to look at his thoughts on cybernetics and the difference between analogic and digital thinking.

II. Paradigm Shifts.

Bateson (1988) says about the paradigm shift to the cybernetic: "As I see it, the root of the matter lies in the contrast between the digital and the analogic or, in another language, between the name and the process that is named" (p. 200; emphasis in the original). Digital thinking is allied with logical systems of defining and naming, such as the student teacher's preoccupation with definitions and procedures. Analogic thinking, on the other hand, is "cybernetic" as in a self-regulating circuit (Bateson, 1972, p. 459). A continuous transactional communication runs among the elements. Bateson's idea was for society to arrive at a more cybernetic, or self-regulating, way of thinking about things. The question of how to accomplish this shift relates directly to my classroom story.

For Bateson, the world is organized into two stochastic systems: evolution (genetics) and biology (mental process). A stochastic system is one that combines random with non-random elements. Whereas historically these two systems (evolution and biology) have vied with one another, Bateson wants to argue that both are indispensable. Rather than combining them into a new synthesis, however, they need to be "alternating" (Bateson, 1988, p. 201). In terms that return us to the significance of his phrase, "the map is not the territory," Bateson (1988) clarifies that "to get from the name to the name of the name, we must go through the process of naming the name" (p. 201; emphasis in the original). One of the ways in which to understand how this learning process might take place is to consider the first of Berman's (1990) three R's: "reflexivity, reciprocity and rootedness" (p. 3). Berman's three R's were inspired by his reading of Bateson. Reflexivity, Berman explains, "involves the deliberate awareness of constructing or using a code" (p. 3). The present alternative to reflexivity, argues Berman, is the conception of knowledge as a mirror. However, it does not take very long for a mirror to "harden" and for us to mistake our world-view for the world (p. 3). Or, in Bateson's language, "we talk as if the Creatura were really Pleromatic" (Bateson & Bateson, 1987, p. 27).

With awareness of the code as a construction come two insights. One insight Berman (1981) identifies with Bateson's notion of limits and thresholds. The other is Bateson's (1988) idea of possibility or "relationship" (p. 17) (discussed in the next section). On thresholds, Bateson (1988) says that "what we, as scientists, can perceive is always limited by threshold . . . Knowledge at any given moment will be a function of the thresholds of our available means of perception" (p. 29). For science, those "means of perception" are instruments or technological apparatus (p. 29). Thus, for example, there is no allowance within a scientific framework for somatic knowledge. Berman (1981) recalls that one of Bateson's favorite quotes came from Pascal, Descartes arch-rival: "The heart has its reasons which the reason does not at all perceive" (p. 197). Bateson was interested in how knowledge, and the naming of knowledge, is constrained by paradigms and how to move past that. He would remind us that the name is not the thing named (Bateson & Bateson, 1987, p. 21). Coming back to my story, instead of asking what a unit is, which is a question about definitions, or of suggesting a pragmatic agreement on what a unit is, Bateson would likely have asked: What can a unit be? Answering this question involves seeing things in relationship to one another.

III. Seeing Things in Relation.

Bateson (1988) articulates his notion of relationships using Goethe's description of a leaf:

A stem is that which bears leaves.
A leaf is that which has a bud in its angle.
A stem is what was once a bud in that position. (p. 18)

Similarly with nouns, predicates and adjectives, says Bateson. These ought to be shown in relation to one another rather than as things-in-themselves (p. 17). The role that relations and connections, or what Bateson calls "patterns," play are analogous to the part "intimations of immortality" play in Wordsworth's ode. Bateson ascribes to the poets a knowledge of which we have lost conscious awareness. Recognition of patterns, and realization of meta-patterns, connects us to a broader realm of possibility by which we can live. "The name is not the thing named." What is it that both I, as instructor, and the student teacher are trying to articulate by our words, "unit" or "teaching-learning strategy"? Bateson (1972) suggests "that "pleroma" and "creatura" are words which we could usefully adopt to construct bridges between worlds (p. 456). One bridge that Bateson identifies is of a meta-level of learning, which consists in an awareness of the code that regulates our living as well as an ability to regulate, adjust, or change it. Bateson suggests "a non-Cartesian mode of scientific reasoning . . . to quote Don Juan's admonition to Carlos Castaneda, 'a path with a heart,' and yet without any corresponding loss of rational clarity" (Berman, 1981, p. 233). In teaching student teachers, that path would involve recognizing where student teachers' understanding begins (the "unit") and ways in which to challenge that learning, thus constructing bridges from creatura to pleroma so as to let "difference" in.

IV. Telling Teaching Stories about Learning.

Bateson, in asking himself whether regions existed that angels could live in but fools dreaded to enter, contemplated his own experiences of learning how to play the violin. He recalled that he persisted in focusing on achieving the right note, and that his goal continuously eluded him: "By continually trying to correct the individual note, I prevented myself from learning that the music resides in the larger sequence" (Bateson & Bateson, 1987, p. 49). Bateson "feared to tread" in those regions that move between "conscious self-correction" and "unconscious obedience to inner calibration" (p. 49). What does it take to break out of one pattern into a new pattern? What does it involve for student teachers to recognize how their previous schooling experiences have shaped their perceptions of what it is possible to do as teachers? How do teacher educators themselves avoid the trap of delivering a preferred curriculum and instead learn to move into regions where only angels tread? What is that "larger sequence" in relation to teaching and learning? As answers to these questions, there is simply Bateson's adage that patterns will become static unless challenged to change. In speaking about the training of a dolphin, Bateson (1988) recounted, the dolphin stubbornly persisted with the same tricks until pushed into inventing his own "routine." Is this not what both teaching and learning are about? Returning to my classroom story in light of Bateson, I imagine a different path:

"The purpose of doing this "unit" is to break into a new place in which other possibilities can be envisioned. My plan won't work for your teaching, because it comes out of where my heart and mind have been. However, the message that I am trying to convey is: Play with the strategies and texts, and create out of your own context. That is what teaching is, and what a "unit," so far as it can be defined, also is."

"But, but, but, but . . .how, how, how . . ."
Don't focus on the individual note.
The map is not the territory.

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Collaborative Testing and Test Anxiety

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Abstract. Prior research concluded that collaborative learning reduces test anxiety. Examination of the evidence used in that research, however, calls into question those conclusions. The present study used an empirical measure of test anxiety and an experimental design to provide an improved estimate of the effect of collaboration in an evaluative context on test anxiety. The findings show no significant difference in test anxiety between students who collaborate on their exam and students who work alone. The ability to organize information is found to have a significant effect on test anxiety and that effect differs between collaborating students and those working alone.

Keywords: test anxiety, collaboration, testing, cooperative learning.

I. Introduction.

Among the many areas of research in teaching and learning, the areas of collaborative learning and test anxiety may be among the most studied. Johnson, Johnson, and Stanne (2000) identify over 900 research studies, over a 100 year period, validating cooperative learning and 194 separate comparisons of specific collaborative learning methods. Even more numerous are studies of test anxiety. Pekrun, Goetz, Titz, and Perry (2002) report over 1200 studies of test anxiety for the period 1974-2000 alone. Surprisingly perhaps, given this volume of studies, only a very few studies have examined the relationship between collaboration in an evaluative context and test anxiety. Even fewer attempt an empirical assessment of this association. Rather, conclusions about a collaboration-test anxiety effect are based on student and teacher impressions. In this paper, we address this gap in the research literature. We examine the effect of collaboration in an evaluative situation on levels and changes in a quantitative measure of test anxiety among two groups of undergraduate college students.

II. Literature Review.

A. Collaborative Learning.

Studies of collaborative learning have documented a range of beneficial outcomes across diverse populations and disciplines. Researchers have documented learning gains among elementary school children (Billington 1994; Fuchs, Fuchs, Karns, Hamlett, Katzaroff, and Dutka 1998), developmental students (Ley, Hodges and Young 1995), and college students (Clark 1994; Giraud and Enders 2000; Gokhale 1995; Grzelkowski 1987; Guest and Murphy 2000; Hanshaw 1982; Harris 1993; Helmericks 1993; Muir and Tracy 1999; Nowak, Miller, and Washburn 1996;

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Rau and Heyl 1990; Reinhart 1999; Russo and Warren 1999; Sernau 1995). At the college level, collaborative learning studies have been conducted in courses in sociology (Grzelkowski 1987; Helmericks 1993; Rau and Heyl 1990; Reinhart 1999; Sernau 1995), psychology (Guest and Murphy 2000; Ley et al 1995), business (Nowak et al 1996), statistics (Giraud and Enders 2000), education (Muir and Tracy 1999), science (Hanshaw 1982), industrial technology (Gokhale 1995); and English composition (Russo and Warren 1999).

Among the learning outcomes identified by proponents of collaboration are increased complexity of thinking, increased motivation to learn, improved performance on oral, written, and multiple choice exams, and greater retention of information (Gamson 1994; Johnson, Johnson, and Stanne 2000). Additionally, collaborative learning fosters cooperation and connections with others (Muir and Tracy 1999; Rau and Heyl 1990), develops skills critical workplace success such as team building and teamwork skills (Nowak et al 1996; Russo and Warren 1999), humanizes the learning experiences (Grzelkowski 1987), eliminates cheating (Grzelkowski 1987; Ley et al 1995), is associated with higher levels of student satisfaction (Chickering and Gamson 1991; Fuchs et al 1998; Giraud and Enders 2000; Sernau 1995; Slavin 1980), and lowers test anxiety (Grzelkowski 1987; Hanshaw 1982; Helmericks 1993; Ley et al 1995; Muir and Tracy 1999; Russo and Warren 1999).

The breadth and generalizability of collaborative learning effects across populations, disciplines, and methods of evaluation seems to make a very compelling case for adopting the collaborative learning format. Closer scrutiny of the evidence, though, may temper enthusiasm for employing collaborative learning as a multi-purpose problem solver. Consider the claim that collaborative learning reduces test anxiety. Of the six studies we located that make such a claim, only Hanshaw (1982) employs an instrument to measure test anxiety. The others base their conclusions about a collaboration-test anxiety effect on teachers' and students' impressions. While those impressions and conclusions may be valid, the absence of empirical evidence leaves them on less sure footing than empirical evidence would provide. Further, the absence of a non-collaborative control group and a pre-collaboration test anxiety baseline against which test anxiety under collaboration can be compared make it all the more difficult to accept prior conclusions about the anxiety reducing effect of collaboration.

B. Test Anxiety.

Test anxiety research has primarily focused on the association between test anxiety and academic achievement. Reviews of that literature find strong consensus on the negative association between test anxiety and academic achievement (Hembree 1988; Seipp 1991). Another large body of work has centered on the measurement of test anxiety. This research generally supports the idea that test anxiety is a two-dimensional construct with a cognitive and an emotional component.

Cognitive test anxiety refers to the inability to retrieve information in an evaluative setting. It is characterized by such conditions as task irrelevant thoughts, excessive fear of failure, worry about letting others down, and negative comparisons with others. Emotional test anxiety refers to physiological reactions to evaluative situations. It includes reactions such as dizziness, nausea, and feelings of panic. Meta-analyses and path analyses have concluded that cognitive test anxiety is the more important dimension of test anxiety for explaining difference in academic achievement. It is more strongly and more consistently associated with test performance (Bandalos, Yates and Thorndike-Christ 1995; Williams 1991).

Two models of the cognitive test anxiety-test performance association have received the most attention. The "interference" model argues that high levels of test anxiety inhibit the ability to recall learned information (Sarason 1986; Wine 1980). The problem is not one of learning, but one of interference with retrieval. Wine (1980) writes that high test anxiety divides the students' cognitive power between focusing on the task and attention to task-irrelevant thoughts. This both inhibits the power to recall and limits the ability to engage in higher order thinking. These factors may explain why students with high test anxiety generally do better on multiple choice exams than on essay exams where the former may require less recall. The "skills deficit" model claims that high test anxiety students have difficulty learning and organizing material, and that this results in poor test performance (Birenbaum and Pinku 1997; Naveh-Benjamin, McKeachie and Lin 1987; Tobias 1985). Students with high test anxiety deal with anxiety through avoidance (Appelhans and Schmeck 2002). They minimize important differences and miss subtle cues about what is important to learn (Cassady and Johnson 2002). Both avoidance of learning and minimization of attention lead to poor test performance. Their test setting anxiety comes from their realization that they are not prepared. The problem is not one of recall, but rather, a lack of preparation due to poor study skills. They do poorly because there is little learned information to recall.

Rather than constituting alternative explanations, the interference and skills deficit models may be complementary (Birenbaum and Pinku 1997; Tobias 1985). They suggest different types of students with different predicted performance levels. Students with good study skills and good ability to organize information, along with low test anxiety should perform well since they have learned the test material and suffer from no inability to recall. Other students are able to learn the material but suffer from retrieval problems in evaluative settings and when the task asks for more cognitive power than they have available. Still others fail to learn and have difficulty organizing material so that they do poor regardless the test situation or test format.

C. Collaborative Testing and Test Anxiety.

Collaborative testing seems to have implications for both interference and skills deficit on test performance. In the collaborative setting, students share their cognitive power and their archive of learned information. Collaboration should boost the ability to retrieve both directly through lowered test anxiety and indirectly as students discuss, reflect on, debate questions and answers. Collaboration should reduce anxiety due to skills deficit since students know they will have the knowledge of another student to aid them. On the other hand, collaboration may increase anxiety for these students if they become anxious over their lack of preparation being exposed to another student.

We hypothesize that cognitive test anxiety will differ between students who collaborate on an exam and those who do not. Collaborating students will have lower test anxiety than students working alone. We also hypothesize that the effect of the ability to organize information on test anxiety will differ between those who collaborate and those who do not. Collaboration will reduce the effect of information organizing skill on test anxiety.

III. Data and Methods.

Our subjects were 131 undergraduate college students enrolled in four sections of an introductory sociology course. All participation was voluntary and only a few students chose not to participate. At the beginning of the course, students were told that they would have the opportunity to participate in a research study on learning that would be conducted in class. Informed consent was gained from those who chose to participate.

Three sections of the course were designated as the experimental group where students would have the opportunity to work in same-sex, randomly assigned pairs on a multiple choice test. The fourth section served as the control group. Basic demographic information on these groups is found in Table 1.

Table 1. Summary of Student and Group Characteristics.

	All	Experimental Group	Control Group	t-statistic[a]
Sex				
Female	79	54	25	0.131
Male	52	37	15	
Minority				
Minority	10	3	7	-2.12*
Non-Minority	121	88	33	
Class Rank				
Freshman	70	52	18	
Sophomore	45	29	16	-1.06
Junior	10	6	4	
Senior	6	4	2	
IO Test 1 Score				
High	51	33	18	
Moderate	66	47	19	-1.54
Low	14	11	3	
IO Test 2 Score				
High	53	36	17	
Moderate	51	40	11	0.734
Low	27	15	12	

Minority refers to non-white students. IO Test 1 and IO Test 2 refer to self-reported ability to organize information
a. t-statistics for the difference between the experimental and control group. *Iindicates a significant difference at the 5% level.

We divided the semester into three approximately equal sections and covered roughly the same amount of material in each section. A multiple choice test was administered at the conclusion of each section. Our present interest is in the changes between tests 1 and 2. All students took the first test individually. Students in the experimental group worked in pairs to completed test 2 while students in the control group continued to work alone.

On the day of the test, and immediately prior to distributing the test forms, we administered a Likert-type test anxiety scale. Scale items are similar to those presented by Cassady and Johnson (2002). We were concerned that students have enough time to finish the test, especially since we anticipated that collaborating would increase completion time, so we used a smaller number of scale items than might otherwise be used.[2] The final seven item scale has an alpha > .84. While the scale includes relatively few items, and that may be a cause of

[2] Test anxiety scales vary in number of scale items. Pekrun et al (2002) report test anxiety scales ranging from 9 to 31 items.

concern, it captures variation sufficient for analysis and for distinguishing different levels of test anxiety. On our scale, the higher the score, the higher the level of test anxiety.

We also collected self-reported information on subject's sex (female = 1 male = 0), minority status (minority = 1 non-minority = 0), and class rank (freshmen = 1 sophomore = 2 junior = 3 senior = 4) to assess within group differences. We would like to have collected information on grade point average (GPA), in order to control for ability, but many of our students were entering freshmen who had not yet earned their first GPA.

Lastly, we measure a student's ability to organization information (IO) as their self reported agreement or disagreement to the two questions "I frequently feel that I have studied the 'wrong' things for the test" and "The harder I work at taking a test or studying for one, the more confused I get". The data were reverse coded and summed so that the higher the sum of their scores on these questions, the higher their ability to organize information.

IV. Analysis and Discussion.

The summary data reported in Table 1 show no significant differences between our experimental and control groups except for minority status. There was a significantly greater percentage of minorities in the control group. This difference should be kept in mind when evaluating any other group differences. Most of our students were female, white, and predominantly either freshmen or sophomores. Although there were no significant differences in the level of IO between our groups, it is interesting to note that in both groups students are more likely to rate their information organization skills as moderate or high than as low.

As shown in Table 2, we find no significant difference in test anxiety between our groups at either test 1 or test 2. There is also no significant difference in the change in anxiety level between test 1 and test 2. Our results do not support the argument that collaborative testing reduces test anxiety. Rather than reduce test anxiety, anxiety is apparently higher at the time of the second test than the first, though not significantly so.[3] While these tests fail to show a significant effect of collaboration on test anxiety, closer examination of the distribution of test anxiety change shows an interesting outcome.

Table 2. Test Anxiety Levels and Change.

	All	Experimental Group	Control Group	t-statistic[a]
Test 1: Anxiety Average	18.10	18.04	17.78	0.770
Test 1: Anxiety Average	18.20	18.13	18.20	-.100
Test 1: Anxiety Average	0.09	0.18	-0.01	0.632

a. t-value for the difference between the mean scores of the experimental and control groups.

The evidence presented in Table 3 shows that while most students in both groups experienced either an increase or a decrease in test anxiety between test 1 and test 2, students in the experimental group were less likely than those in the control group to experience an increase in test anxiety. Whereas test anxiety increased 36 percent of experimental students, it increased for almost 43 percent of control group students. Collaborative testing may not affect the overall amount of test anxiety, but it appears to affect the distribution of changes in anxiety.

[3] t values are not reported.

Table 3. Distribution of Test Anxiety Score Changes by Group.

Experimental Group			Control Group		
Change[a]	Percent	Cumulative Percent	Change	Percent	Cumulative Percent
-6			-6	2.5%	2.5%
-5	3.3%	3.3%	-5	2.5	5.0
-4	4.4	7.7	-4	2.5	7.5
-3	2.2	9.9	-3	10.0	17.5
-2	11.0	20.9	-2	10.0	27.5
-1	15.4	36.3	-1	15.0	42.5
0	17.6	53.8	0	20.0	62.5
+1	17.6	71.4	+1	7.5	70.0
+2	15.4	86.8	+2	12.5	82.5
+3	6.6	93.4	+3	12.5	95.0
+4	5.5	98.9	+4	2.5	97.5
+5	1.1	100.0%	+5	2.5	100.0%

A Calculated as anxiety at test 1 minus anxiety at test 2. Negative values indicate an increase in anxiety from test 1 to test 2.

The top half of Table 4 presents the results of regressing test 1 anxiety level on four predictors for both groups. The bottom half of that table presents the corresponding results for test 2 anxiety level. In all four equations, IO has a significant negative effect on test anxiety. It also has the largest effect on test anxiety except on test 1 for the control group where class rank has the largest effect. These results suggest that information organizing skills are important for improved test performance not only because they lead to better preparation for a test, but also indirectly because they reduce the cognitive test anxiety that others have shown to be detrimental to test performance.

The effect for class rank is not consistently significant, but the effect in all equations is in the direction one might hypothesize. Given their greater experience with examinations, their greater likelihood of having learned to cope with test anxiety, the greater probability that they have developed study skills, it is probably not surprising that more senior students have lower levels of test anxiety compared to newer students.

The effect of minority status is interesting. Again, although the effect is generally not significant, the sign of the effect is stable across equations. Minority students express lower levels of test anxiety than majority students. This is perhaps surprising given the generally lower standardized test scores of minority students. To the extent that those scores reflect ability, one would expect their test anxiety scores to be higher since other research shows that high test anxiety is correlated with low ability. Alternatively, minority students may receive more emotional support from family versus peers. This mode of support has been shown to significantly lower test anxiety (Orpen 1996). Whatever the explanation, it appears that collaboration may boost the effect of minority status on test anxiety, net of the other independent variables. Additional research is needed to verify and explain this association.

A final contrast of interest is the change in the size of the effect of IO for the experimental group. While the change in IO for the control group is minimal, there is a substantial decrease in the experimental group. Collaboration may be responsible for this reduction. Students with poor information organizing skills, who might otherwise be anxious about the test, may feel less cognitive test anxiety knowing that they will have the knowledge of another student to call upon. Further study on the reaction of students with poor IO skills to collaboration could help us better understand how collaborative testing affects test anxiety.

Table 4: Regression Results: Test Anxiety on Subject Characteristics.

	Experimental Group	Control Group
Test 1 Anxiety		
Sex	+0.696	+1.090
Class Rank	-0.279	-2.090**
Minority	-3.000	-1.590
IO Test 1	-2.120**	-2.570**
Adj. R^2	0.150***	0.372***
Test 2 Anxiety		
Sex	+0.995	-0.120
Class Rank	-0.321	-1.855**
Minority	-3.920*	-1.660
IO Test 2	-1.610**	-2.760**
Adj. R^2	0.148***	0.442***

The experimental group took test 2 in same-sex pairs.
**Significant at the 5% level.
***Significant at the 1% level.

V. Conclusion.

Collaborative learning is one of the most commonly used and studied teaching techniques with researchers finding collaboration leading to increased complexity of thinking, increased motivation to learn, improved performance on oral, written, and multiple choice exams, and greater retention of information (Gamson 1994; Johnson, Johnson, and Stanne 2000). Collaborative learning enhances behavioral outcomes such as fostering cooperation and connections with others (Muir and Tracy 1999; Rau and Heyl 1990), team building and teamwork skills (Nowak et al 1996; Russo and Warren 1999), and eliminates cheating (Grzelkowski 1987; Ley et al 1995). In the affective realm, collaboration creates a more humane learning environment (Grzelkowski 1987), is associated with higher levels of student satisfaction (Chickering and Gamson 1991; Fuchs et al 1998; Giraud and Enders 2000; Sernau 1995; Slavin 1980), and lowers test anxiety (Grzelkowski 1987; Hanshaw 1982; Helmericks 1993; Ley et al 1995; Muir and Tracy 1999; Russo and Warren 1999).

Our review of the evidence for one of these outcomes, namely test anxiety, finds that conclusions about the effect of collaboration may be premature. Of the collaboration-test anxiety studies we found, the evidence on which those conclusions were based is generally weak for reasons we outlined above. While no one study is adequate for drawing a final conclusion, we believe the present study employs a more rigorous design than earlier studies and begins to bring us closer to that conclusion.

We find no significant difference in test anxiety between students who collaborate and those who do not. Our findings are based on comparisons between two tests when students did not also engage in prior collaborative learning or get to know their test partners prior to the collaborative test. Additional research comparing changes in anxiety across multiple exams, not just between two, that examines alternative testing formats, or that examines difference in test anxiety when students engage in collaborative learning in addition to collaborative testing may lead to different conclusions.

Interestingly, collaboration may have an effect on the distribution of test anxiety changes that is not apparent when comparing group means. Understanding the distribution of change may help identify which students most benefit from collaborative testing. This is another area where additional research is needed. We also find that information organizing skills are important for reducing test anxiety and that the effect of those skills on anxiety depends on whether students collaborate or work alone on their test. Students with poor information organizing skills, who might otherwise be anxious about the test, may feel less cognitive test anxiety knowing that they will have the knowledge of another student to call upon. Further study of the reaction of students with poor IO skills to collaboration could help us better understand how collaborative testing affects test anxiety.

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The themes of the Journal reflect the breadth of interest in the pedagogy forum. The themes of articles include:

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Journal of the Scholarship of Teaching and Learning, Vol. 4, No. 2, September 2004, pp. 47 - 49.

Style Sheet for the *Journal of the Scholarship of Teaching and Learning*

John Dewey[1] and Marie Curie[2]

Abstract: This paper provides the style sheet for the Journal of the Scholarship of Teaching and Learning. Manuscripts submitted for publication should adhere to these guidelines.

Keywords: radiation, metacognition, identity theory, constructivism, educational philosophy.

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The final manuscript should be prepared in 12-point, Times New Roman, and single-spaced. Submissions should be double-spaced. All margins should be 1 inch. The text should be fully left- and right-justified. The title (in 16 point bold) and author's name (in 12 pt. bold) should be at the top of the first page. The author's name should be followed by a footnote reference that provides the author's institutional affiliation and address. The abstract should be indented 0.5" left and right from the margins, and should be in italics.

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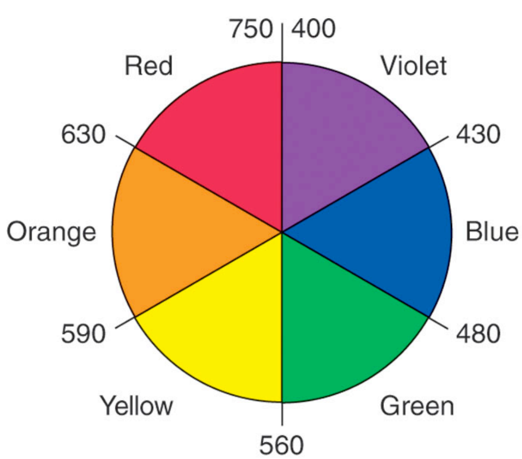

Figure 1. Color wheel with wavelengths indicated in millimicrons. Opposite colors are complementary.

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Appendix

Please insert any appendices after the acknowledgments. They should be labeled as follows:

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