Report on the Visual Physics Program

Visual Physics

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Abstract
Visual Physics (VP) is a systematic reform of the lab and recitation sessions in Physics 218, the calculus-based freshman physics course. The VP strategy is described and experience from the first year of trial sections are presented. We conducted assessments of its effectiveness in teaching physics and technical writing, comparing to sections taught using the traditional approach. The exam scores, along with technical writing scores and force concept inventory test scores, for the students in VP lab are compared to those in traditional lab in fall 2003 semester. Although the statistics are limited, the data indicate that the VP lab with a rigorous technical writing component improves students’ exam scores, their mastery of the physics in the course, and their technical writing ability.
Introduction

PHYS218 is the calculus-based freshman physics course at Texas A&M University. It is required for all physics majors and for many majors in the Colleges of Science, Engineering and Geosciences. PHYS218 is a 4-credit-hour course, consisting of 3 hours of lecture, 1 hour of problem-solving recitation, and 2 hours of laboratory. For many years the lab and recitation sessions have been led by graduate teaching assistants (TAs) with little training or supervision by faculty and without any clear connection to the lectures. Lab reports were perfunctory (filling in the blanks on tear-out sheets) and involved no technical writing.

Several attempts have been made to improve the quality of feedback students receive on homework (such as an online homework submission system, AMES, developed by Prof. Toback and now implemented in WebCT). This strategy has helped to reduce the number of D’s and F’s, but we have not seen an increase in the number of A’s students receive on exams. This could be an indication that students still rely on memorizing problem-solving steps instead of knowing how to analyze critically to apply thinking skills beyond memorization and comprehension, skills such as analysis or synthesis. Further the professors’ lectures incorporated narrowly-defined teaching strategies that are ineffective for students having different learning styles (see Figure 1).

Figure 1: Sketch of learning styles. Taken from handouts of “Effective Teaching,” Richard M. Felder (N.C. State Univ.), Workshop, Texas A&M University, January 30-31, 1998.
Visual Physics

Visual Physics (VP) is a fresh approach to the recitations and laboratory experiments that accompany the lectures of the calculus-based first-year physics course PHYS218. The approach was inspired by the work of Heller and Heller at the University of Minnesota\(^1\) and others\(^2\). There are three components to the approach:

- The recitations employ strategies of cooperative learning groups, interactive engagement, and context-rich problems to enhance students’ conceptual grasp and problem-solving strategies. Students are grouped into 3-person teams and assigned concept-rich problems in a timed quiz-style format. The TA circulates and serves as mentor and coach as the teams grapple with each problem in succession.

- The laboratories employ a video-based image acquisition of mechanics experiments and spreadsheet-based physics analysis, to foster visualization of physical phenomena and minimize abstractions between observation and analysis. Students are grouped in the same 3-person teams, with structured roles as builder/operator, data acquisition, and team leader. The roles are rotated in each team for successive experiments, and teams are shuffled mid-semester.

- The students receive instruction in technical writing as a component of the course (one evening lecture each week by an experienced technical writing instructor), and the laboratory reports are written in the format of short technical papers using the template that is now the dominant mode of communication in all fields of science and engineering. The reports are graded both for physics and for technical writing.

The inspiration for VP draws from decades of research in how students learn first-year physics\(^3\). Conceptual understanding is best stimulated by involving students interactively to solve concept-rich problems. Conceptual understanding and problem-solving skills are best improved as students work in small teams, using concept-rich problems, with an ‘expert’ (TA) circulating to guide students through analytical road-blocks when they occur. Laboratory experiments are most effective when they are structured in a way that maximizes direct visualization, minimizes cookbook format, and builds the students’ abilities at numerical modeling in the language of physics. Instruction in technical writing is an ideal marriage with first-year physics when the laboratory reports are used as the writing assignments in the genre of the short technical paper.

Much depends upon the pedagogical training, support and coaching of the graduate teaching assistants who teach VP. They must be comfortable with the interactive engagement methods that incorporate context-rich problem solving, model-building and group interactions. They must have mastery of the visual toolkit used in the experiments and how it can be used to foster student visualization skills and inquiry during the conduct of each experiment. They must learn to grade using a rubric, both for student participation in lab and recitation and for lab reports.

VP was first used at Texas A&M University in Fall 2002, and in Fall 2003 a thorough assessment was made, comparing 6 sections taught using VP to 6 sections taught using the conventional approach to recitation and lab. The results are summarized in the next section. Exam scores were improved by 5%, final letter grade was improved by ¼ grade point, and mastery of concepts, measured using the Force Concept Inventory, was improved by 10%. The students also learned how to write well in the genre of a short technical paper, as demonstrated by the attached example.

The spirit of Visual Physics is to create a learning experience in lab and recitation that builds students’ understanding and confidence in using the tools of physics so that they can succeed in the lecture course and emerge with a mastery that can support them in subsequent courses.
Evaluations

In preparing for Fall 2003, Prof. McIntyre expanded the scope of implementation and prepared for a serious assessment of the new strategy in reference to the traditional strategy. He recruited Prof. Cindy Raisor, an experienced technical writing instructor in our English Department, and her TA Megan Gilbert, to provide instruction and grading in technical writing. He also recruited Ms. Cathy Ezrailson, a seasoned physics teacher who is here at Texas A&M completing her Ph.D. in Science Education, to train and supervise the Physics TAs in the recitation techniques of the Minnesota Model and to conduct an authentic assessment. The results of her work will constitute the body of her Ph.D. thesis and are presented above in the Assessment section.

In addition to 3 Honors sections, 12 sections of the regular (non-Honors) 218 course taught by Profs. Kamon, Sokolov, and Toback were split into 6 VP sections and 6 control sections. Several assessment tools (FCI, VASS) were administered at the beginning of the course and are being done again at the end. Student background information was collected to analyze the populations of each sample. The performance on course exams was tracked to evaluate the effectiveness of VP in enhancing learning of the physics. The results are summarized below.

Analysis 1: Students’ academic preparation in 2003

It is ideal to prepare two groups of students whose academic backgrounds are identical. We measure their academic preparation before taking PHYS 218 course by looking at their class rankings at high school and their SAT verbal scores. We find that students in TR0/TR1/TR2 group has slightly higher high-school class rankings and SAT verbal scores than those in VP0/VP1/VP2 group, but not significantly.

Each student also took Force Concept Inventory (FCI) test\(^1\) at the beginning of the semester. The average FCI scores are:

\[
TR = 15.9 \pm 0.5 \ (N = 128) \quad \text{vs.} \quad VP = 15.7 \pm 0.6 \ (N = 92)
\]

Each error is calculated as r.m.s./\(\sqrt{N}\), where r.m.s. is a root-mean-square of the corresponding distribution. Based on those data, it is concluded that there is no difference in students’ academic preparation.

Analysis 2: Is the VP program asking too much of students?

From the beginning, there was concern about an extensive workload in the VP program: students were required to take one-hour TW class each week with extensive writing of their lab reports. Table 2 is a summary of number of Q-drop students. We do not see any particular effect in Q-drops due to any increased workload in the VP program.

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\(^1\) The Force Concept Inventory (FCI) is a multiple-choice “test” designed to assess student understanding of the most basic concepts in Newtonian mechanics.
Table 2: Number of Q-drop students, compared to the number of students who completed the PHYS-218 course in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>VP Completed</th>
<th>Q-drop</th>
<th>TR Completed</th>
<th>Q-drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sokolov</td>
<td>34</td>
<td>5</td>
<td>52</td>
<td>7</td>
</tr>
<tr>
<td>Toback</td>
<td>32</td>
<td>5</td>
<td>46</td>
<td>2</td>
</tr>
<tr>
<td>Kamon</td>
<td>26</td>
<td>4</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>92</td>
<td>14 (15% of 92)</td>
<td>128</td>
<td>16 (13% of 128)</td>
</tr>
<tr>
<td></td>
<td>58 with TW</td>
<td>9 (16% of 58)</td>
<td>76</td>
<td>9 (12% of 76)</td>
</tr>
</tbody>
</table>

Analysis 3: How does the VP program help the students’ final letter grades?

Our analysis addresses two questions:

(i) How does the TW instruction help the students within the VP program?
(ii) How does the VP lab compared to TR lab?

These can be evaluated by looking at student’s final letter grades. Figure 2 shows the letter grade distributions for two groups: (a) VP1/VP2 vs. VP0 and (b) VP0/VP1/VP2 vs. TR0/TR1/TR2.

Although these statistics are limited, preliminary results show that VP helped to improve the students’ grades with TW instruction. This is also seen in a lower percentage of students who received D’s and F’s.
Analysis 4: Exam improvement in Profs. Sokolov, Toback, and Kamon’s classes

An interesting question is how the VP program enhances the students’ exam scores. There are three mid-term exams and the final exam. Main topics in each exam are:

Exam 1  Motion in 1 and 2 dimensions
Exam 2  Newton’s law, Work and Energy
Exam 3  Momentum conservation, rotational kinematics/dynamics
Final Exam  Comprehensive including simple harmonic oscillation

Exam 1 consists of the simplest problems (i.e., kinematics) in PHYS-218, while the Final Exam problem can be the most complex problems. One can see a trend from the average score of each exam. VP lab and recitation styles should have impacted all exams equally for VP sections, while the TW should have affected context-rich exams. It should be noted that Profs. Sokolov and Kamon’s exams were most consistent in the exam style. Prof. Kamon’s exams were suitable for VP (with TW) groups, while Prof. Sokolov’s exams were suitable for both VP (without TW) and TR groups. Prof. Toback’s exams unfortunately changed in style during the semester.

The average score of each exam for each group in Profs. Sokolov, Toback, and Kamon’s classes is listed in Table 3. The VP sections of Profs. Sokolov and Kamon’s score consistently higher in its average, while Prof. Toback’s VP sections do not show any sign of improvement compared to TR group.

Table 3: Average scores of FCI (max. 30) and exams (max. 100). Each error is calculated as r.m.s./\sqrt{N}.

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Group</th>
<th>FCI</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Final Exam</th>
<th>Difference from Exam 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sokolov</td>
<td>TR0</td>
<td>15.6±0.8</td>
<td>74.1±2.2</td>
<td>79.6</td>
<td>72.1</td>
<td>62.9±2.5</td>
<td>−11.2</td>
</tr>
<tr>
<td></td>
<td>VP0</td>
<td>15.0±0.9</td>
<td>79.1±2.3</td>
<td>80.5</td>
<td>78.4</td>
<td>68.8±2.2</td>
<td>−10.3</td>
</tr>
<tr>
<td>Toback</td>
<td>TR1</td>
<td>16.2±0.9</td>
<td>72.5±2.9</td>
<td>63.6</td>
<td>65.8</td>
<td>64.3±2.8</td>
<td>−8.2</td>
</tr>
<tr>
<td></td>
<td>VP1</td>
<td>15.3±1.0</td>
<td>71.7±3.7</td>
<td>63.8</td>
<td>67.8</td>
<td>60.2±2.8</td>
<td>−11.5</td>
</tr>
<tr>
<td>Kamon</td>
<td>TR2</td>
<td>16.4±1.1</td>
<td>82.0±2.8</td>
<td>66.0</td>
<td>64.8</td>
<td>63.7±3.3</td>
<td>−18.3</td>
</tr>
<tr>
<td></td>
<td>VP2</td>
<td>17.1±1.3</td>
<td>82.2±3.2</td>
<td>75.1</td>
<td>70.2</td>
<td>75.5±2.3</td>
<td>−6.7</td>
</tr>
</tbody>
</table>

As mentioned earlier, Prof. Toback’s exam style varied from one to another. Exam 3 and Final Exam were most consistent with other professor’s styles, while Exam 1 and Exam 2 were markedly different. Profs. Toback and Sokolov gave a nearly identical final exam, grading procedures and final grading scales were completely different. Although a nearly identical common final exam was given to Profs. Sokolov and Toback’s students, the difference in results can be traced to one unusually low performing section in Prof. Toback’s class. Many students in this section improved but some did not. The results tend to skew the average score.

A possible explanation of the results in Table 3 is that an impact of TW is seen in Prof. Kamon’s class along with suitable exam style/format. We analyze Prof. Kamon’s exams in more details below.
Analysis 5: Exam improvement in Prof. Kamon’s class

As mentioned earlier, Prof. Kamon’s exams were consistent in its style and suitable for measuring the impact of TW. Figure 3 shows the change in the average score of each exam (Exam 2, 3, and Final Exam) relative to Exam 1 for VP and TR (control) groups. The average scores of Exam 1 from VP and TR groups are 82.2 and 82.0, indicating the initial academic backgrounds are approximately equal between the two groups. This is consistent with Analysis 1. We, however, see a dramatic improvement for VP compared to TR by the end of semester. Is this improvement due to changes in his lecture during 2003?

![Figure 3: Change of average score of each exam for students in VP2 (Visual Physics Group) and TR2 (Control Group) in Prof. Kamon’s PHYS-218 class in fall 2003 semester, relative to Exam 1. X = 1, 2, 3, and 4 correspond to Exam 1, 2, 3 and final exam. Note that the average scores of Exam 1 from VP2 and TR2 groups are 82.2 and 82.0. Each error bar is calculated as r.m.s./sqrt(N).](image)

Prof. Kamon has taught PHYS-218 class for three fall semesters in 2001, 2002, and 2003 in the same consistent style: using the same textbook, using PowerPoint for his lectures, and using context-rich problems for exams. One way to compare three semesters is to look at the average score of each exam, as listed in Table 4. Exam 1 is always the highest score. This is because it tested the simplest physics concept using a minimum level of math skills. The final exam is always lower, because it tests all physics concepts comprehensively. The distributions of Exam 1 and Final Exam scores are shown in Figure 4. The shapes of the distributions in Exam 1 are similar, again indicating the initial academic backgrounds are approximately equal between the two
groups. Further, the data show that very few students in VP score low (e.g., below 60) on the Final Exam in Figure 4(d) compared with Figure 4(c).

Table 4: Average scores in Prof. Kamon’s exams.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Group</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Final Exam</th>
<th>Difference from Exam 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2001</td>
<td>TR (N = 105)</td>
<td>78.9</td>
<td>63.6</td>
<td>64.9</td>
<td>60.1</td>
<td>−18.8</td>
</tr>
<tr>
<td>Fall 2002</td>
<td>TR (N = 93)</td>
<td>84.7</td>
<td>75.5</td>
<td>69.7</td>
<td>73.6</td>
<td>−11.1</td>
</tr>
<tr>
<td>Fall 2003</td>
<td>TR (N = 30)</td>
<td>82.0±2.8</td>
<td>66.0</td>
<td>64.8</td>
<td>63.7±3.3</td>
<td>−18.3</td>
</tr>
<tr>
<td>Fall 2003</td>
<td>VP (N = 26)</td>
<td>82.2±3.2</td>
<td>75.1</td>
<td>70.2</td>
<td>75.5±2.3</td>
<td>−6.7</td>
</tr>
</tbody>
</table>

Figure 4: [Fall 2003 Semester] Distributions of Exam 1 scores for TR2 (control) and VP2 groups in Prof. Kamon’s class are shown in (a) and (b), respectively.
The shapes of the distributions are similar, indicating the initial academic backgrounds are approximately equal between the two groups. The corresponding distributions of the Final Exam scores are shown in (c) and (d), whose average scores are 63.7 and 75.5, respectively. Please notice about a fraction of students whose Final Exam scores are better than 60%.

In the next stage, we analyze a correlation plot between Exam 1 score and Final exam score in each of three fall semesters in 2001, 2002 and 2003. See Figure 5. No significant change is seen for students who received the same TR lab for all three semesters. Further, one can examine a fraction of students whose Final exam scores are better than 60%. Is the correlation seen in VP2 in Fig. 5(c) a real effect or just a fluctuation?

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**Figure 5:** Correlation between Exam 1 and Final Exam in Prof. Kamon’s PHYS-218 classes for three fall semesters in 2001, 2002 and 2003. All students in (a) and (b) took TR lab, while there are two groups in (c); VP lab with TW session (red solid circles) and TR lab without TW session (blue solid triangles). Please notice about a fraction of students whose Final Exam scores are better than 60%.
One way to test whether the correlation is due to a statistical fluctuation is to re-plot Figures 5(a) and 5(b), but with groups with smaller number of students. We chose the first 2 sections as one group and the last 2 sections as another in each semester. Figures 6(a) and 6(b) are the correlation plots for the fall 2001 semester; 6(c) and 6(d) are for the fall 2002 semester. None of four plots look closer to the one seen in VP2.

In summary, we observe a significant impact of the VP (with TW) program at least for Prof. Kamon’s class in the fall 2003 semester.

Figure 6: [Fall 2001 and 2002 Semesters] Same as in Figure 5, but showing each group of two sections, simulating a similar size of students in VP2 group in the fall 2003 semester. All students in (a)-(d) took TR lab. Please notice about a fraction of students whose Final Exam scores are better than 60%.
Analysis 6: Impact of TW instruction in writing scientific lab report

One of goals in the VP program is to teach students how to write a scientific lab report in the early stage of their academic careers. We evaluated two sets of lab reports from three groups:

Two lab reports: Pre-test reports were submitted after the students had received 2-3 TW sessions of instruction; therefore, even for the pre-test, the students had received some instruction, while post-lab reports included the last lab reports the students submitted.

Three groups: For non-honors, Prof. Sokolov’s VP group (VP0) was not required to attend TW class, while Profs. Toback and Kamon’s VP groups (VP1 and VP2) were required. In addition, honors with TW were added as the 3rd group for this analysis.

Figure 7 shows the results of evaluation of the lab reports based in two different grading methods: (a) analytically on 100-point scale, (b) holistically on 4-point scale. It is natural that students in honors sections score higher than students in VP0, VP1, and VP2 groups. However, their TW skills, as reflected by their scores, did improve dramatically. Further, the group not receiving TW instruction, VP0 group, showed no improvement between pre- and post-lab reports.

It should again be noted that Profs. Kamon’s and Sokolov’s exams were most consistent in the exam style. Prof. Toback’s exams changed his exam style during the semester. Prof. Kamon’s exams were suitable for VP groups, while Prof. Sokolov’s exams were for TR groups as far as the impact of the TW is concerned. VP lab and recitation styles should have impacted all exams equally for VP sections. An improvement seen in Prof. Kamon’s class (see Table 3) could be an indication of the impact of the TW class.

(a) Pre/Post Visual-Physics Lab Reports
(graded analytically on 100-point scale)

(b) Pre/Post Visual-Physics Lab Reports
(graded holistically on 4-point scale)

Figure 7: Pre- and post-VP lab reports are graded (a) analytically and (b) holistically. The results from three groups are shown: Non-honors without TW instruction (VP0), non-Honors with TW instruction (VP1 and VP2), and Honors with TW instruction in Prof. McIntyre’s class.
3. Conclusion – Learning by Writing – and Plan

The goal of the VP program is to provide a coherent effort to improve students’ understanding of physics (i.e., exams) and writing ability of scientific papers (i.e., lab reports) in the early stages of their academic careers. The data from the Fall 2003 semester shows that the students’ learning is maximized with the TW class.

In Spring 2004 we arranged that one faculty member (Prof. Kamon) coordinates the VP program (12 sections):

(1) Coordinator: Teruki Kamon
   TW instructor: Cindy Raisor
   TA instructor: Cathy Ezrailson
   Mentor TA: Amanda Woodward

(2) Weekly coordination meeting (Kamon, Raisor, Ezrailson)
   Weekly TA instruction and training meeting (Ezrailson, Kamon, all TAs)

The structure allows us more communication between TAs, lecture instructors, Prof. Raisor, and Ms. Ezrailson. This also includes Prof. Kamon’s attending recitation/lab regularly and grading lab reports to understand students’ performance in lab.

We also plan to monitor VP students from Fall 2003 in PHYS-208 in Spring 2004. We are looking forward to seeing more comprehensive results in the spring semester.
Appendix A: Early Bird Eyes – from Spring 2004 Semester

We plot a correlation between Exam 1 score vs. Lab 1 (TW portion) score for VP students in Profs. Schuessler, Toback and Teizer’s classes. Note that some students are re-taking the course, so that they do not repeat the VP lab and TW class. Those are scattered along with y axis. Some students simply do not submit their Lab-1 reports. They are also along with the y axis. Similarly, students who missed Exam 1 are seen along with the x axis.

Among those who completed both TW and Exam 1, if the TW scores are 85% or better, there are NO students (except one) whose Exam 1 scores are below 80%. This is expected, because good students (in exams) can follow the instructions given in TW classes and to be able to complete the writing requirements. If the TW scores are around 65% (average), then we see a broad distribution of Exam 1 score between 30% and 100%. As mentioned earlier, Exam 1 tested kinematics of motion in 1 and 2 dimensions, so that we expect a weak correlation in general.
Appendix B: Visual Physics – the details

Recitation. Students are grouped into teams of three for both recitation and lab, and both activities are conducted in the lab room. In recitation, VP uses the tools of cooperative learning groups and context-rich problems to build student conceptual learning and problem-solving skills. The TA begins the recitation session by asking if any students had difficulties with particular homework problems on the current assignment. From the responses, the TA spends some time explaining the problem-solving strategy and mode of thinking needed to attack the problems in question. Then the TA assigns a context-rich problem and the students are given 10-15 minutes to attack the problem. Each student team works as a team on the problem. The TA circulates the room, observing each group as they work. When he observes a group stuck in their efforts, he explains to that group the point where they are stuck, so that they get going again. At the end of the allotted time, he collects their work and repeats the process with another context-rich problem. Typically the class will complete three context-rich problems in the course of the recitation period.

There are three points of departure between this strategy our traditional expository technique. The TA does not work problems for the students! He explains the problem-solving strategy and the concepts at play in homework problems with which they are having difficulty, then during the quiz problems he serves as a coach to help with roadblocks just when any team gets stuck. Pedagogic research shows that is the exact moment when real learning happens most effectively. The students work as teams on the quiz problems. Within the dynamics of each team, typically one student will understand a given problem better than the other two, and serves as a focused peer mentor – a more effective learning strategy. The sticking points encountered by different teams are frequently on different specifics; by intervening at the team level the TA can provide focused instruction when those students are ready for it, then move to the next group.

Laboratory. The physics topics and apparatus of the laboratory experiments are largely the same as those in the traditional course, but the experience is wholly different. The students learn to work as a team. Each experiment is structured within three or more problems, using the same equipment to study several different questions. The work of each team is structured, with roles of doer (sets up the equipment and conducting the experiment), scribe (operates the data acquisition and logs the data), and manager (maintains oversight vis a vis objectives and makes preliminary analysis to see that results make sense). The team rotates roles on successive problems.

Each problem is inquiry-driven, with opportunities and credit for minimizing and quantifying sources of error and investigating departures from expectations.

The experiments use video to enhance the visualization of kinematics and dynamics. Each setup is equipped with a space frame and a high-resolution video camera which is linked via firewire to a PC. The image sequence from the camera is acquired directly into LabView, the most widely used data acquisition software used in both research and industry. LabView has a powerful intuitive toolkit, that enables the students to cursor-select points within each frame and automatically transfer the x-y screen coordinates to three columns (frame #, x, y) of an EXCEL spreadsheet. The students construct their analysis of the data in the spreadsheet. That enables them to easily produce graphics of their data, to perform regression fits to data, etc.

The students develop proficiency in REAL software and hardware, not dead-end educational packages. The software used in the course is LabView, EXCEL, WORD, and AutoCad. These
are professional tools that the students will use throughout their college education and then in their careers as either scientists or engineers. We are equipping them in their first semester!

*Each student writes a serious 2-page scientific paper for each lab report.* At the end of each 2-week experiment, each student of a team is assigned a different problem to write up as a paper. The paper is written in the form a short technical paper, using the full set of format and style rules that apply to journal articles and papers for conference proceedings. The papers are submitted electronically. You can read samples of their work for yourself at [http://www-english.tamu.edu/pers/fac/raisor/presentationhome.html](http://www-english.tamu.edu/pers/fac/raisor/presentationhome.html).

*The students receive instruction in and credit for technical writing.* We employ Prof. Cindy Raisor, an experienced teacher of English composition and technical writing, to teach evening classes (required of all students!) in the many elements of technical writing pertinent to the genre of a short technical paper – the ubiquitous mode of communication among scientists and engineers. Her lectures span the gamut of what it takes to write well, from word usage and sentence structure to paragraph organization to the organization of a paper and effective use of graphics and tables. If you peruse the examples of the students’ papers at her web site, you will get the flavor of how this instruction is building the students into able writers during their first semester at TAMU. Their lab reports are graded twice – by the TA for physics content and by Prof. Raisor and her TA for technical writing.

**Technical Writing**

Our students are becoming less and less proficient at writing well. An increasing fraction of students are escaping the traditional core requirements of English composition and technical writing. Yet all but a few of our students write so poorly it brings tears to the eyes to read their efforts.

Heller addressed this problem at Minnesota by teaming with the English department to offer technical writing instruction in a co-registered lecture with Freshman Physics in which the writing assignments were the actual lab reports for the experiments in the physics course. Both English and Physics faculty were enthusiastic about the outcome: students were trained in writing few-page technical papers, the genre that is ubiquitous as the primary mode of communication in all fields of science and engineering. And they received that training in their freshman year, when it could benefit through the rest of their college courses. (At Texas A&M today, registration is so jammed for the technical writing course that typically only seniors can enroll.)

1. [http://groups.physics.umn.edu/physed/](http://groups.physics.umn.edu/physed/)