Analyzing Student Laboratory Reports*

Vince Kuo

K. Heller, P. Heller,

and the Physics Education Research Group

University of Minnesota

http://www.physics.umn.edu/groups/physed/

vkuo@physics.spa.umn.edu

***Supported in part by NSF grant #9651339**

Outline

- **Importance of Laboratory Reports & Purpose of the pilot study**
- **Setting**
- **Design of Pilot Study**
- **Results & Discussions**
- **What have we learned & Where we are going**

Importance of Laboratory Reports

- **Course**
  - **students are expected to write reports to communicate:**
    - **physics**
    - **data analysis**
    - **what they've learned**
    - **what they've not learned**
  - **Learning through synthesis of information**

- **Clear & Concise technical communication**
  - **Sought-after skills by employers**
    - **Ability to formulate writing of technical data and analyses**
    - **Ability to communicate effectively through this writing**

Purpose of Pilot Study

Explore the quality of student laboratory reports

- Can we implement simple scheme?
- Is that useful
  - effective communication enables TAs to easily identify where students need help
  - implement more effective coaching strategies
- Expectations
  - improvement
  - big effects in small sample

Setting

- **Lecture**
  - **~200 students / 1 lecturer**
  - **3 hours / week**
- **Recitation**
  - **15 students / section**
  - **1 hour / week**
- **Laboratory**
  - **15 students / section**
  - **2 hours / week**

★ Note:

All parts of the course are integrated such that the problems in lab and recitation are concurrent with the topics being covered in lecture

Laboratory

- **problem-solving-based**
- **cooperative group (3 students per group)**
- **6 laboratory topics - each topic consists of several problems & lasts 2 - 3 weeks**
- **on average students work through 2 problems per week**
- **each student hands in individual reports for each topic**
- **TA assigns each student a different problem at the end of each topic**

Guideline for grading laboratory reports

Problem Report:	Score
ORGANIZATION **(clear and readable; correct grammar and spelling; section headings provided; physics stated correctly)**	
DATA AND DATA TABLES (GROUP PREDICTIONS) **(clear and readable; units and assigned uncertainties clearly stated)**	
RESULTS **(results clearly indicated; correct, logical, and well-organized calculations with uncertainties indicated; scales, labels and uncertainties on graphs; physics stated correctly)**	
CONCLUSIONS **(comparison to prediction & theory discussed with physics stated correctly ; possible sources of uncertainties identified; attention called to experimental problems)**	

Given to TAs & Students in Lab Manual

Design

- **Introductory calculus-based mechanics laboratory**
- **Randomly selected TA (first year) asked to copy all reports before grading**
- **Sample consisted of 15 Students followed through a 15-week semester**
- **Laboratory reports analyzed based on 5 criteria designed for evaluating written communication**

TAs

- 1st & 2nd year graduate students
- First time teaching a class
- 2 week Orientation & Weekly Seminar
- Weekly teaching team meetings
- Orientation on evaluating written communication
  - Introduction to general criteria
  - Individual grading of sample student laboratory reports
  - Whole group discussion on personal grading schemes
  - Consensus on grading criteria
  - Criteria for Evaluating Written Communication

General Criteria for evaluating technical Reports

(Dr. Lee-Ann K. Breuch, Dept. Of Rhetoric, U of MN)

- **Content:** What is the subject? What information needs to be included?
- **Context:** What is expected in the discipline for this type of document?
- **Audience:** To whom is the document written? How will it be used?
- **Organization:** How can the information be best organized?
- **Support:** What details, facts, and evidence can be used to illustrate main points? Are they accurate?

Example of quality levels - Content

	Satisfactory	Adequate	Poor
Addresses content accurately and thoroughly	Includes accurate and complete technical information, including equations, explanations, theorems, and data.	Includes accurate technical information, but has missed some important information.	Does not include accurate or complete information.
Score	3	2	1

Example

Satisfactory:

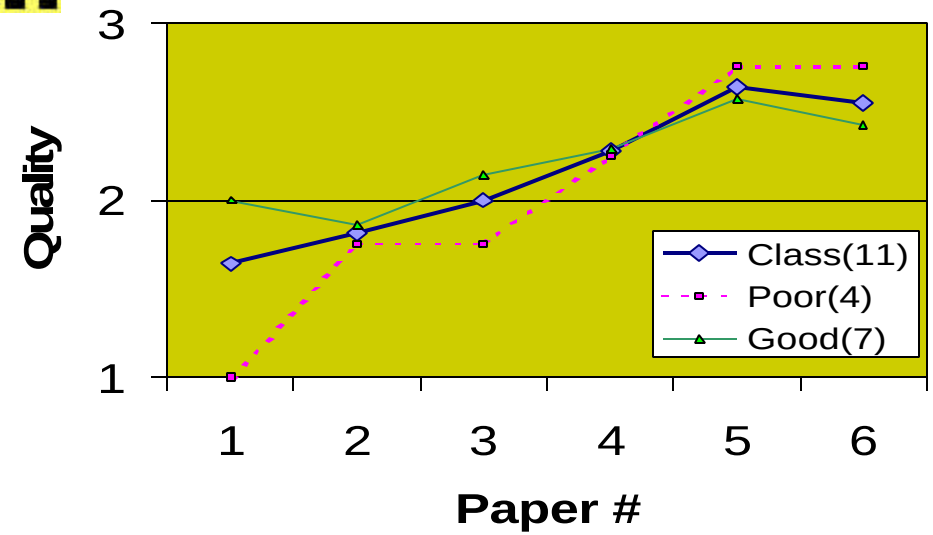
- **While the beam was rotating we timed how long it took to make five revolutions. We did this to determine the angular velocity, w. Once we knew w we plugged that value into the equation v = Rw, where R is the radius. Our group and I concluded that the linear velocity (v) of a point on the beam increases when the radius increases with a constant angular velocity. There is a graph at the end of the report that shows this relationship for easier understanding.**

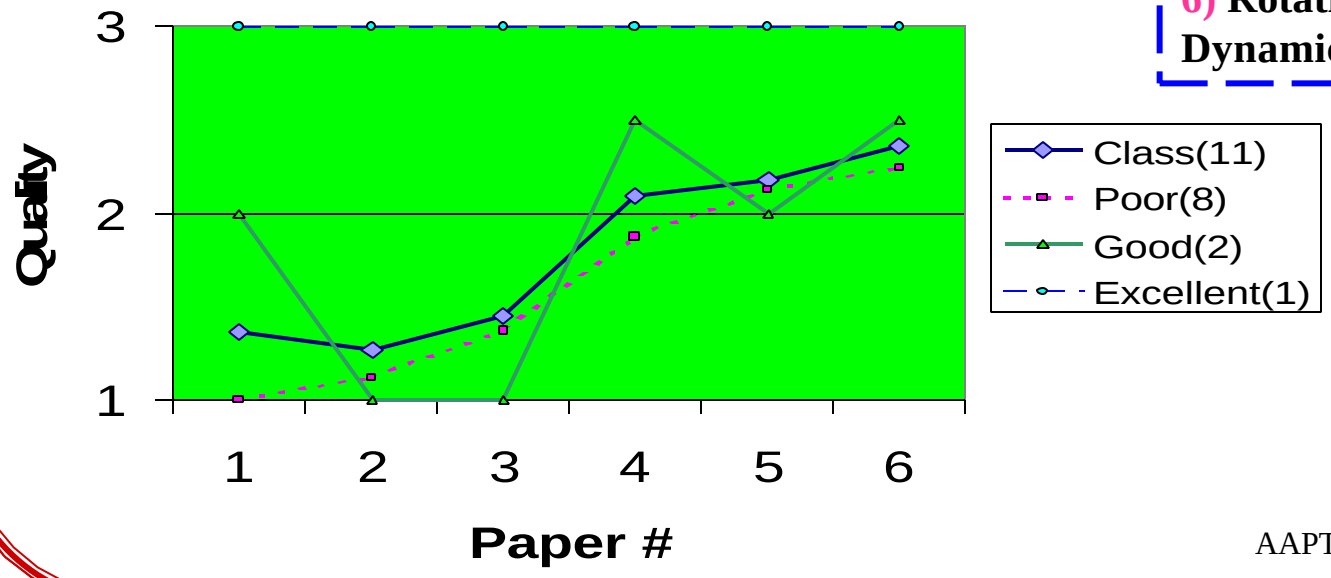
Poor:

- **I observed that the acceleration is zero at the time where the cart switches from going up the track to down the track. This is what we predicted to happen. Our group ... The graph is a constant slope from left to right because the acceleration is always negative and this is why the graph is an upside down parabola. This lab has helped me understand ... The acceleration is always negative (in this respect) which is a little hard to comprehend at first but it was nice to observe this in lab.**

Results

- **One class of 15 students**
  - **11 of which had all 6 laboratory reports from the entire 15-week semester (n = 11)**
- **Each student is placed into one of three groups based on the rating of the first report**
  - **Poor**
  - **Adequate**
  - **Satisfactory**





Topic of paper number:

1) 1-D Kinematics

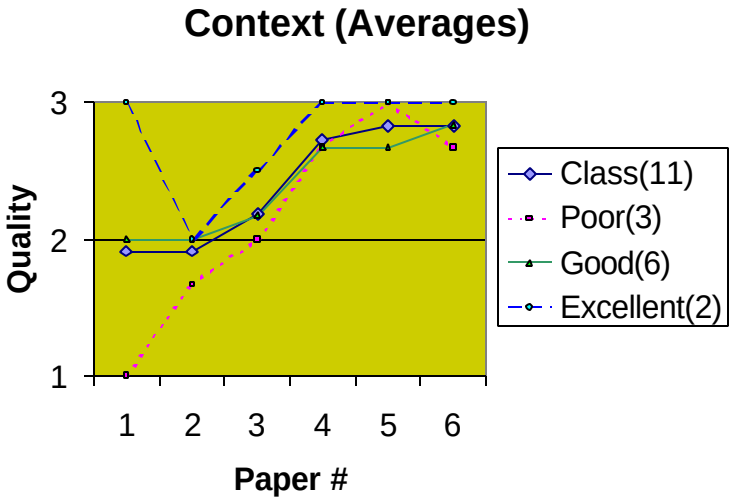
2) 2-D Kinematics

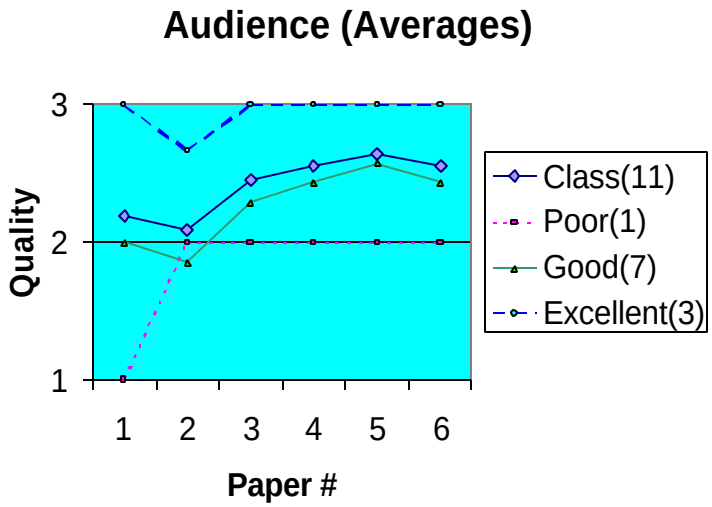
3) Forces

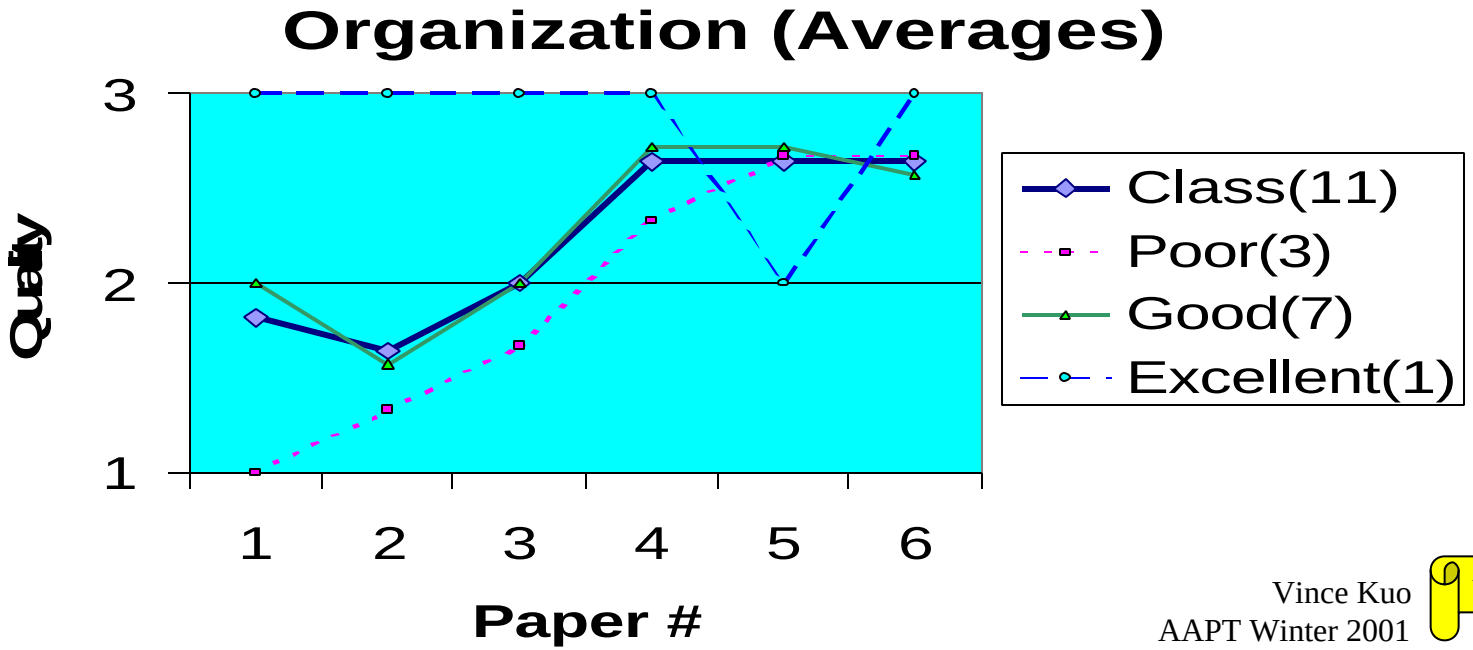
4) Conservation of Energy and Momentum

5) Rotational Kinematics

6) Rotational Dynamics


Context (Averages)
Quality
3
2
1
1 2 3 4 5 6
Paper #
Class(11)
Poor(3)
Good(6)
Excellent(2)


Audience (Averages)
Quality
3
2
1
1 2 3 4 5 6
Paper #
Class(11)
Poor(1)
Good(7)
Excellent(3)


Organization (Averages)
Quality
3
2
1
1 2 3 4 5 6
Paper #
Class(11)
Poor(3)
Good(7)
Excellent(1)

Discussions

- **Students at all starting levels showed signs of improvement in each of the criteria**
  - **Except for those students that were initially-satisfactory, average rating of each group reached approximately the same quality by the end of the 15-week semester**

Discussions

- **Identifiable increases in quality apparent by 3rd or 4th report**
  - **content, context, audience, & organization**
- **Slower increases in quality of support (Physics is in here)**
  - **majority of students only slightly higher than "adequate"**

What have we learned?

- **What we do seemed to be helpful**
  - **Students seemed to have improved through the course of a semester**
- **This evaluation seemed useful**

Where are we going?

- **Check replication & expand sample size**
- **Comparison between Foreign and American TA's**
- **Correlation of performance and other measures of knowledge**

http://www.physics.umn.edu/groups/physed/
vkuo@physics.spa.umn.edu

Content

Content	1	2	3	4	5	6	Lab average	Course grade
1	2	3	3	2	3	2	90.2	A
2	2	1	1	2	2	2	71.1	C-
3	1	1	2	2	3	3	75.4	C+
4	2	2	2	2	2	3	74.2	B-
5	2	2	1	1	2	2	70.5	C
6	2	2	2	3	3	3	84.0	B-
7	2	2	3	3	3	2	79.1	B-
8	1	1	1	2	3	3	71.7	C-
9	2	1	3	3	3	3	67.4	C-
10	1	2	1	2	2	2	79.7	B-
11	1	3	3	3	3	3	87.7	B+
Average (Class)	1.64	1.82	2.00	2.27	2.64	2.55		
Average (Poor)	1.00	1.75	1.75	2.25	2.75	2.75		
Average (Good)	2.00	1.86	2.14	2.29	2.57	2.43		

Context

Context	1	2	3	4	5	6	Lab average	Course grade
1	3	3	3	3	3	3	90.2	A
2	2	2	1	2	2	2	71.1	C-
3	2	2	3	3	3	3	75.4	C+
4	2	2	2	3	3	3	74.2	B-
5	2	2	2	3	2	3	70.5	C
6	2	2	2	2	3	3	84.0	B-
7	1	1	2	3	3	2	79.1	B-
8	1	2	1	3	3	3	71.7	C-
9	3	1	2	3	3	3	67.4	C-
10	1	2	3	2	3	3	79.7	B-
11	2	2	3	3	3	3	87.7	B+
Average (Class)	1.91	1.91	2.18	2.73	2.82	2.82		
Average (Poor)	1.00	1.67	2.00	2.67	3.00	2.67		
Average (Good)	2.00	2.00	2.17	2.67	2.67	2.83		
Average (Excellent)	3.00	2.00	2.50	3.00	3.00	3.00		

Audience

Audience	1	2	3	4	5	6	Lab average	Course grade
1	3	3	3	3	3	3	**90.2**	**A**
2	2	1	1	1	2	2	**71.1**	**C-**
3	2	2	2	3	3	3	**75.4**	**C+**
4	2	2	3	3	3	3	**74.2**	**B-**
5	2	2	3	2	2	2	**70.5**	**C**
6	2	2	2	3	3	3	**84.0**	**B-**
7	2	2	3	3	3	2	**79.1**	**B-**
8	1	2	2	2	2	2	**71.7**	**C-**
9	3	2	3	3	3	3	**67.4**	**C-**
10	2	2	2	2	2	2	**79.7**	**B-**
11	3	3	3	3	3	3	**87.7**	**B+**
Average (Class)	2.18	2.09	2.45	2.55	2.64	2.55		
Average (Poor)	1.00	2.00	2.00	2.00	2.00	2.00		
Average (Good)	2.00	1.86	2.29	2.43	2.57	2.43		
Average (Excellent)	3.00	2.67	3.00	3.00	3.00	3.00		

Organization

Organization	1	2	3	4	5	6	Lab average	Course grade
1	3	3	3	3	2	3	90.2	A
2	1	1	1	1	2	2	71.1	C-
3	1	1	2	3	3	3	75.4	C+
4	2	2	2	3	3	3	74.2	B-
5	2	1	3	3	2	2	70.5	C
6	2	2	2	2	3	3	84.0	B-
7	2	2	2	3	3	2	79.1	B-
8	2	1	1	2	2	2	71.7	C-
9	2	1	2	3	3	3	67.4	C-
10	1	2	2	3	3	3	79.7	B-
11	2	2	2	3	3	3	87.7	B+
Average (Class)	1.82	1.64	2.00	2.64	2.64	2.64		
Average (Poor)	1.00	1.33	1.67	2.33	2.67	2.67		
Average (Good)	2.00	1.57	2.00	2.71	2.71	2.57		
Average (Excellent)	3.00	3.00	3.00	3.00	2.00	3.00		

Support

Support	1	2	3	4	5	6	Lab average	Course grade
1	3	3	3	3	3	3	90.2	A
2	2	1	1	2	1	2	71.1	C-
3	1	1	1	1	2	2	75.4	C+
4	1	1	1	2	2	3	74.2	B-
5	1	1	1	1	1	2	70.5	C
6	1	1	2	2	2	3	84.0	B-
7	1	1	2	3	3	2	79.1	B-
8	1	1	1	2	2	2	71.7	C-
9	2	1	1	3	3	3	67.4	C-
10	1	1	1	2	2	2	79.7	B-
11	1	2	2	2	3	2	87.7	B+
Average (Class)	1.36	1.27	1.45	2.09	2.18	2.36		
Average (Poor)	1.00	1.13	1.38	1.88	2.13	2.25		
Average (Good)	2.00	1.00	1.00	2.50	2.00	2.50		
Average (Excellent)	3.00	3.00	3.00	3.00	3.00	3.00		