SUMMARY OF TEACHING ACTIVITIES: 2003

Below, I have presented my own personal reflection of my teaching activities as well as sample copies of my syllabus, course materials, exams and evaluations for each class that I taught during this period. The classes discussed here are:

Spring 2003

Physical Measurement and Instrumentation – PMI (PHYS636)

Physics Education Seminar (PHYS807)

Fall 2003

Physics of Solids (PHYS655)

General Physics-I Recitation (PHYS113)

You may access complete documentation for the courses above on K-State Online.
Please go to: http://online.ksu.edu
Login as:
User name: physfaculty@phys.ksu.edu
Password: (Please contact me)
Click on the highlighted courses below.

COURSE NUMBER	COURSE NAME
Using KSU Libraries	Basic Library Instruction - non-credit, free
PHYS101	PHYSICAL WORLD - I (Rebello, Fall 2002)
PHYS636	PHYSICAL MEASUREMENT & INSTRUMENTATION (Rebello, Spring 2003)
PHYS655	PHYSICS OF SOLIDS (Rebello, Fall 2003)
PHYS807	Physics Education Seminar (Rebello, Spring 2003)
phys 113	F03 - General Physics 1
F03 PHYS 114 Lecture	General Physics 2 Lecture, Fall 2003
phys 214 A	ENGINEERING PHYSICS 2 STUDIO A (Rebello, Fall 2002)
phys_452	Contemporary Physics (Zollman Spring 2003)

NOTE: To find documentation for my materials for my General Physics – I Recitation Section please click on "phys_113" in the list above. Then click on "Class Modules" in the left panel and then on "11:30 Recitation: Instructor – Sanjay Rebello"

Spring 2003

<u>*Physical Measurement and Instrumentation – PMI (PHYS636*</u>)

This was my second time teaching PMI at K-State. I had previously taught electronics, both analog and digital as separate courses at Clarion. However, the last time at K-State I had followed the lab manual written by Dr. Brett DePaola quite closely. Based on feedback from students the last time, as well as my own ideas, I decided to try a new approach, which was fundamentally different in some ways.

The new curriculum covered the same content as the previous one, although it differed significantly in the pedagogy. There were two significant differences. 1) The students were seldom told the circuit that they needed to build. Rather they were expected to go through a process of guided discovery to design the circuit, then simulate it, then build it, and compare the real measurements with the simulations. 2) We followed the modeling cycle pedagogy that included two phases: In the model development phase, students explored the electrical characteristics of a device by performing I-V or other measurements. Based on these I-V measurements and past knowledge they built a model of how the device works. The typical representation for this model was an equivalent circuit consisting of previously studied electrical elements (e.g. equivalent circuit of a diode based on switches, resistors and batteries). In the model deployment phase, students applied the equivalent circuit model to predict the behavior of the device when it was embedded in a circuit. They compared their predictions first with simulations and then with real measurements.

Some of the other features of the pedagogy used included collaborative learning, self-reflection, and Socratic dialog. Students were guided by a script on an activity sheet that asked them leading questions. My role and that of the teaching assistant was to walk around the class and interact with the students as they worked through the questions on the activity sheets. In keeping with the idea of Socratic dialog, seldom did we answer questions which students asked directly. Often we responded to students' questions by asking them other leading questions. Sometimes, when a problem was widely prevalent in class, I interrupted the class to go over this issue in a lecture-based format. This intervention became less likely as the course continued mainly because different students were at different stages of completion of the activities and it made more sense to address students' concerns as they arose in small groups. To be sure that the students were on the right track I began to introduce 'stopping points' in the activities. At these stopping points students were expected to talk with me and/or the TA about their approach and what they had discovered. The main purpose of these 'stopping points' was to ensure that students did not waste too much time following unproductive strategies or approaches for too long.

At the very beginning of the course, I realized that the pedagogy used in the course might be novel to most students. Therefore, this approach was made explicit to the students from the beginning and its intentions were made clear. They were told that this class would most likely be a departure from previous classes that they may have had. They were required to record all of their work in a permanent lab notebook. It was emphasized to the students that even wrong approaches could be productive learning experiences and that everything that they did – right or wrong – should be recorded in the notebook. In addition to the students, the pedagogy was also explained to the TA. I was fortunate to have a cooperative and dedicated TA (Flint Pierce) in this course who bought into the pedagogical approach and engaged in Socratic dialog with the students whenever required, rather than giving them the answers.

There was one mid-term exam and a final exam. The mid-semester exam was a take-home exam and the and the final exam was an oral exam. Both mid-terms included paper-and-pencil calculation and design problems as well as simulations to verify the paper-and-pencil design. Since I had changed the pedagogy from before I asked some of the same questions that I asked the previous year to see if students would still be able to solve these questions after using the modified pedagogy. I found that students were equally proficient at solving the exam questions. Moreover, they often used new strategies to solve problems and started from first principles in their calculations rather than following a pre-defined recipe. Students also seem to have developed superior modeling skills as was evidenced by the types of questions that they were able to solve on the final exam. One of these questions required students to look at the I-V curves of a device and work backwards to construct an equivalent circuit model for the device. All of the students who were asked this question were successfully able to solve it. The device in question was MOSFET, which we had not gotten a chance to cover in the course because of the lack of time. However, in spite of not having covered that particular device, students were able to develop an equivalent circuit model of it based on the hypothetical experimental evidence presented to them. I do not believe students in the course that I taught the previous year would have developed this skill.

My overall impressions from the new approach were positive. I also solicited feedback from students through an online mid-semester survey (using the K-State Survey System) as well as additional questions on the TEVAL at the end of the semester. Interactive engagement approaches usually result in coverage of less content. In this case, I covered about 70% of the material I had covered in the previous time I taught the course without the modified pedagogy. Through my observation of students' work and feedback from students, I believe I have identified the materials that need to be revised so that coverage can be increased while still maintaining the same pedagogical approach. Some areas where time was spent unproductively are the modeling of complicated devices such as bipolar transistors or flip-flops. In hindsight more scaffolding and some amount of direct instruction could be provided to the students in these topics so that less time is spent following unproductive leads as the students construct their models for these devices.

Other comments from the students reflected the need for a little more direct instruction to tie up loose ends. So, the next time I teach this course, I plan to spend at least one hour each week going over the main ideas that students would have learned through their activities. However, the lectures will not be a substitute for the discovery-based approach; rather they will mainly synthesize what students have already learned through this approach.

Based on my experiences in this course, I presented a poster at the 2003 Summer Meeting of the American Association of Physics Teachers. One of the students in the course, Kara Gray is a co-author for this poster. Kara is also completing her research in physics education towards an M.S. in Physics. Her research is unrelated to the course; however her knowledge of physics education research coupled with her role as a student in the course, gave her a unique perspective to provide me with formative feedback as the course progressed.

Results from student evaluations as well as handout slides from the poster are attached. I would like to thank the following individuals for their useful comments and support throughout the course:

Dr. Brett DePaola was helpful in providing me with the laboratory manual that was initial framework for the content of this course. Although, I modified the pedagogy, I was still following the content that Dr. DePaola had covered during the previous times that he taught the course.

Mr. Peter Nelson was especially useful in helping me set up the lab. He helped procure and put up the inexpensive white boards that I used in the class. He also lent me an old projection system and helped me purchase and transport the laptops that I used in the class from State Surplus in Topeka. Mr. Nelson along with Mr. Mark Newman helped reconfigure the furniture in the class.

Mr. Flint Pierce was an excellent TA. He was very cooperative with implementing the course pedagogy. He was always responsive to students' needs in the classroom and guided them along in the spirit of Socratic dialog. He also proofread and photocopied the instructional materials prepared for the course.

Physics Education Seminar (PHYS807)

This was my second time conducting the Seminar. This course assignment may not traditionally be considered teaching, since it overlaps quite significantly with research. However, in a sense, it could also be considered "training" or "apprenticeship" of new inductees (graduate or undergraduate) students in this field.

In this spirit, I organized the seminar a little differently from the way in which it was organized previously. The format for the seminar is described on the following page. The format was only moderately successful. The most important hurdle to the format was that most participants did not read the papers beforehand. Therefore the discussions were often uninspiring. Also, most of the first year graduate students did not participate.

Since then we have reverted back to the original format for the seminar.

Fall 2003

<u>*Physics of Solids (PHYS655*)</u>

I was both excited and apprehensive when I was assigned this course. I was excited because solid state physics was an area that I was always interested in. In fact, it is the area in which I did my doctoral research. I was apprehensive, because it would be my first time teaching this course at K-State. I had taught solid state physics once in my previous position at Clarion University, however it was offered as a summer course to be taught in an individualized instruction format to only two students over a three-week period. Therefore, I knew that this experience would be quite different from the one I had at Clarion.

Based on my positive experiences with the modified pedagogy that I implemented in PMI the previous semester (see above) and my own knowledge of, and should I say bias toward active learning, I decided to use a similar pedagogy in this course. I began by having students learn the concepts by going through 'Tutorials' – hands-on as well as computer-based activities that they would collaboratively perform in class, that would enable them to learn the concepts by themselves. My role would be that of a facilitator. As I had done in PMI, I articulated this approach to students on the first day of class. The approach appeared to work for the first two weeks of class or so. The topics covered during this period included crystal structures. I used models – both real and on the computer for students to notice patterns in crystal structures and then categorize these in terms of their similarities and differences. The approach was often very slow and time consuming. Additionally, I realized that the approach would be difficult, if not impossible to adopt when the topics (e.g. reciprocal lattice or density of states) were conceptually abstract and mathematically difficult. At the very least, I realized that it would need significant work to be able to design instructional materials that could enable students to learn these concepts by themselves. I knew I did not have the time, knowledge or experience at this time to do that. Therefore, I decided to revert to a more instructor dominated approach of direct lecturing.

I created lectures on the computer that I projected in class. Although the book by Kittel was the official text for the course, I soon discovered that some other texts did a better job at explaining some of the concepts. Therefore, in my lectures I tried to synthesize material from different books. Handouts of the lectures were also posted on K-State Online. In class, I used to interject the lectures with Tutorial exercises. Rather than be exploratory exercises, as was the case previously, these were now application exercises. Typically these were problems that I believed could be solved in a few minutes in class.

I believe that teaching from pre-prepared lectures helped me stay organized in class and also cover all of the material. Often I could focus on going over material without spending time on the detailed calculation, but rather showing students the general scheme and then focusing on the concepts. Overall, based on a mid-semester evaluation that I conducted online (using the K-State Survey System) students liked the lectures. There were some criticisms of the Tutorial though. Students felt that the Tutorials did not help them gain a deeper understanding in any way. They pointed out that many of the Tutorial exercises were long and often ended up adding to the homework. The homework too was criticized for being too out of touch with the material in the course, and more mathematically challenging than conceptually insightful.

I tried to address some of these concerns in the remaining weeks of the semester. First, I changed the Tutorial questions. I focused on questions that could be finished in a few minutes and did not involve as many detailed calculations as the homework questions did. I also put more thought into choosing the homework questions.

There were two take-home mid-semester exams and one take-home final exam. Each mid-term exam had at least one question that required numerical calculations. I believe that numerical calculation is a topic that most students do not get enough exposure to in a traditional course, but the skill to do these types of calculations often is used by computational researchers in the field. Therefore, I wanted to give students some flavor for this. In addition to the exams and homework, students were also expected to talk with one or more condensed matter research groups and present the research done by these groups in a 20 minute long talk at the end of the semester. I also had students have three lab engagements during which they visited the Semiconductor Lab and observed a researcher perform experiments related to the course. In the three visits they learned about X-ray diffraction, Hall measurements and conductivity measurements. I also organized two invited lectures from researchers in the department to talk about their work pertaining to solid-state physics.

In terms of content coverage, I was able to cover all of the topics that I had originally intended to except Superconductivity. However, I did cover some of the topics in greater depth than I had originally anticipated. For instance, I spent more time covering semiconductor devices than originally planned. This departure from the original plan was mainly because the students were more interested in this topic. Almost all of the students were graduate students who had clear ideas about what topics they were most interested in.

If I were to teach this course again, I would make the following changes 1) In terms of content, I would spend a little less time on crystal structure, which would leave more time for other topics toward the end of the course. I would change the time I spent on semiconductor devices because I believe it is an important topic and one that has vast practical applications. 2) I would not discontinue the Tutorials, but make sure that they are short exercises that are more conceptually based than calculation oriented and can be completed in a few minutes in class. 3) I would change the official text for the course. I may have one or more recommended texts, but the book by Kittel would not be designated as the foremost text in the course. 4) I would incorporate more simulations and computational work in the course, not just in the exams but also in the homework.

There are several individuals whom I would like to thank in connection with this course.

Dr. Jingyu Lin and Dr. Hongxing Jiang allowed me to avail the assistance of their research staff and to use the research facilities of the Semiconductor Group for the laboratory experiments that students observed and participated in during the course.

Dr. Jingyu Lin was also helpful in talking to me about her previous experiences with the course and sharing the syllabus, as well as the list of experiments that she had students perform in the course when she taught it previously.

Dr. Christopher Sorensen provided his graduate student (Tahereh Mokhtari) to present a lecture on their research to the class as an invited speaker.

Drs. Kai Zhu and Zhaoyang Fan helped the class with the X-Ray diffraction experiment.

Dr. Jing Li helped the class with the conductivity and Hall measurement experiment.

Dr. Ahlam Al-Rawi presented her research on molecular dynamics as an invited speaker.

Ms. Tahereh Mokhtari presented her doctoral research on soft condensed matter physics.

Mr. Peter Nelson lent me models of crystal structures during the first two weeks of the class.

General Physics-I Recitation (PHYS113)

I was assigned to teach one recitation section in General Physics-I. I had taught recitation in General Physics-II previously, when I was here as a post-doc. Therefore, I was quite comfortable with the format for this course and what the students expected in the recitation.

There were some aspects that were different from my previous experience. The most notable of which was the use of online homework using WebAssign. Students were expected to turn in their homework the day before the recitation section. This meant that students often completed their homework before they came into the recitation section. Several of these students were not interested in the recitation section, because they used to go over the homework in class that had already been completed. Although, I used to focus on the problem solving procedure that could be applied to problems other than the homework problem, they did not find the recitation helpful.

I realized that this was the case, both through anecdotal feedback as well as from the mid-term survey. Therefore, I changed my strategy for the course. Rather than solve homework problems, I solved problems that were different from the homework, but similar enough to be helpful on the exams. As before, I tried to present a strategy that could be broadly applied to several problems and was not specific to the problem at hand. I created Problem Solving Strategy handouts that laid out the strategy as well as an example of how the strategy was applied. Then I displayed the strategy in class using a projector while I solved the problem at hand on the board. This practice was meant to demonstrate how the strategy could be applied to specific problems.

There were some complaints from the students in connection with the differences between the problem strategies that I demonstrated and those that they had learned in the lecture. These differences sometimes resulted in students getting points taken off exams for not following the strategy learned in the lecture and following my strategy instead. In the future, I will make it my responsibility to communicate with the lecture instructor and try to come up with a consistent strategy so that students are not confused by being presented with two methods.

I would like to thank the following individuals for this course:

Dr. Ruma De' for substituting for my class once when I was out of town on official business.

Mr. Zdeslav Hrepic for substituting for my class when I was out of town on two occasions on official business.

Mr. Peter Nelson for setting up the viewing screen for projection in my class, often at short notice.