

ACTIVITY BASED PHYSICS INSTITUTES: IN-SERVICE TEACHER PROFESSIONAL DEVELOPMENT WITH COMPUTER SUPPORTED TOOLS AND PEDAGOGY

David R. Sokoloff, *Department of Physics, University of Oregon, Eugene, OR USA*

In the past 16 years effective curricular materials have been developed that are based on the outcomes of physics education research, employ new pedagogical approaches, and utilize exciting computer-based tools for collection, display and analysis of scientific data. During this time period, many school districts have purchased the technology needed to implement these new strategies. Yet many secondary physics and physical science teachers lack the training to make effective use of these approaches and tools. The Activity Based Physics (ABP) Group has considerable experience in developing curricula and computer tools for the active learning of physics and physical science. Group members have used their own physics education research and the research of others to inform these curriculum development activities. This has resulted in the *Activity Based Physics Suite*, a collection of curricular materials—most of which are computer-supported. A subset of the *Physics Suite* materials have been collected on an *Activity Based Physics High School CD*, and are available for secondary school classroom use at a very affordable price. The ABP Group has also been active since 1987 in designing and presenting professional development programs that address the problems teachers have in implementing active learning approaches in their classrooms. This paper will report on the *Activity Based Physics Institutes*, their design and their successes in changing physics pedagogy in secondary schools using research-based, technology-rich curricula.

Introduction--Activity Based Physics

In the past 16 years effective curricular materials have been developed that are based on the outcomes of physics education research, employ new pedagogical approaches, and utilize exciting computer-based tools for collection, display and analysis of scientific data. During this time period, many school districts have purchased the technology needed to implement these new strategies. Yet many secondary physics and physical science teachers still do not have the technology available to them and/or lack the training to make effective use of these approaches and tools. While a wide range of professional development programs has been developed to assist in-service teachers in working with specific curricula and computer-based tools or in acquiring basic computer skills, little comprehensive research exists that documents the effectiveness of these programs. In fact, researchers have observed that drive-in workshops, summer institutes, and isolated coursework have limited utility for transforming high school teachers as practitioners, action researchers, and local leaders for reformed physics education. (Hammerman, 1995; Martin-Kniep, Sussman & Meltzer, 1995). Continuous investigation and growth through critical analysis of classroom practice, student learning, and the teacher's own learning is crucial for teachers who wish to adopt the more powerful pedagogies advocated in educational reform (Schifter & Fostnot, 1993; Beatty, 1999).

A number of communities of physics teachers have themselves sought ways to extend what they learn in workshops with their own continuing research, as in the case of the Bay Area Physics Teacher Action Research Group [PTARG] where their collaboration endured for years. (Feldman, 1996; 1998). In almost all of these instances, faculty and their doctoral students at graduate research universities or members of educational research groups [such as EDC and TERC] served as facilitators/mentors to groups and to individual high school teachers and community college instructors. Often, the relationship between the teachers and their mentors endured for years resulting in collaborations for research (Feldman & Minstrell, 2000) and for curriculum development (Camp, et al., 1994).

Since 1986, the Activity Based Physics (ABP) Group has been developing curricula and computer tools to enhance active learning of physics and physical science, and conducting professional development workshops designed to help teachers use these materials effectively. Table 1 lists current members of the Group. Group members have conducted physics education research (Sokoloff &

TABLE 1: Current Members of the Activity Based Physics Group

1. Martin Baumberger , Chestnut Hill Acad.	6. Edward F. Redish , University of MD
2. Patrick J. Cooney , Millersville University	7. David R. Sokoloff , University of OR
3. Karen Cummings , So. Conn. State Univ.	8. Ronald K. Thornton , Tufts University
4. John S. Garrett , Sheldon HS (retired)	9. Maxine C. Willis , Gettysburg High School
5. Priscilla W. Laws , Dickinson College	

Thornton, 1997; Thornton & Sokoloff, 1990, 1997, 1998; Thornton, 1996; Laws, 1991, 1997(2); Redish et. al., 1997) and used the research of others (for example McDermott, 1991; McDermott & Redish, 1999; Halloun & Hestenes, 1985; Hake, 1998) to inform their development of commercially distributed, research-based, award winning instructional materials and computer tools that have been shown through educational research to be highly effective in helping students learn physics.. Members have had major funding from NSF, FIPSE, U.S. Dept. of Ed., the Dana Foundation and the Howard Hughes Medical Institute. This has culminated in the *Activity Based Physics Suite*, a collection of curricular materials, developed by members of the ABP Group. Table 2 describes the *Suite* curricular materials and Table 3 describes the computer tools.

The *Suite* materials and tools are based on physics education research, and all have the same underlying educational philosophy. The *Suite* will be published by John Wiley in January, 2004 in conjunction with a new research-based text, *Understanding Physics*. (Cummings, 2004.) All of the curricular materials have been designed for flexible use. They are published in printed and electronic forms to enable teachers to combine and modify them to meet the needs of different student populations. Also, an informative new book by E.F. Redish, *Teaching Physics with the Physics Suite* (Redish, 2003), is available from the publisher at no cost. A subset of the *Physics Suite* materials have been collected on an *Activity Based Physics High School CD* (available from Vernier Software and Technology and PASCO Scientific), and are available for secondary school classroom use at a very affordable price. In addition to curricular materials, the *CD* includes a *Teacher Resource Guide*--to support adaptation of the materials to teachers' own classroom settings, and an *Action Research Kit*--to support local research on student learning.

TABLE 2: Curricular Materials from the Activity Based Physics Suite

Interactive Lecture Demonstrations (ILD): Live demonstrations with enhanced learning from predictions, small group discussions, and comparison with real-time results graphed using Microcomputer-Based Laboratory (MBL) tools. *Most introductory physics topics*. (Sokoloff & Thornton, 1997, 2004; Thornton & Sokoloff, 1999.)

RealTime Physics Active Learning Laboratories (RTP): Series of laboratory modules that use MBL tools to help students develop important physics concepts while acquiring vital laboratory skills. *Mechanics, Heat and Thermodynamics, Light and Optics and Electric Circuits*. (Sokoloff, Laws & Thornton, 1998 (1), 1998 (2), 2000, 2004; Thornton & Sokoloff, 1997.)

Tools for Scientific Thinking (TST): Laboratory curriculum for teachers who want to replace some traditional laboratories with ones using MBL tools to teach physics concepts. *Motion and Force and Heat and Temperature*. (Sokoloff & Thornton, 1992; Thornton & Sokoloff, 1993.)

Workshop Physics (WP): Curriculum that supports honors and AP classes by replacing lectures and formal laboratories with activities that guide student inquiry. Tools include spreadsheets, MBL and digital video analysis. *Includes most traditional introductory topics.* (Laws, 1997(1).)

Explorations in Physics (EiP): Interdisciplinary curriculum emphasizing topics needed to satisfy new science standards. Each module includes 12-15 hours of guided inquiry followed by 12-15 hours of topic-related open-ended projects chosen by small student teams. Spreadsheets, MBL and video analysis tools are used. *Variety of physical science topics.* (Jackson, Laws & Franklin, 2002.)

The following two curricula developed by L.C. McDermott and members of the University of Washington Physics Education Group, do not make use of technology:

Physics by Inquiry: A guided inquiry, workshop style curriculum in which students are guided in small groups with carefully prepared worksheets to reason through simple physical observations and experiments. *Activities available for most introductory physics topics.* (McDermott et. al., 1996, 1997(1).)

Tutorials in Introductory Physics: Small group-learning activities with worksheets that emphasize concept building and qualitative reasoning. *Tutorials available for most topics.* (McDermott et. al., 1997(2), 2002.)

TABLE 3: Physics Suite Computer Tools

Calculator-Based Laboratory Tools (CBL): Interface and software that allow data from electronic sensors to be transmitted to a graphing calculator and graphed in real time. (Vernier.)

Graphical Analysis: Software that allows students to graph data entered by hand or from other software packages such as *VideoPoint*, *Visualizer* or from MBL or CBL systems. (Vernier.)

Microcomputer-Based Laboratory Tools (MBL): Interface and software that allow data from electronic sensors to be transmitted to a computer for real-time graphing and analysis. The most popular of these are the LabPro/LoggerPro and Data Studio systems. (Vernier & PASCO.)

VideoPoint[®]: Software that enables users to extract position data from frames of a classroom generated or supplied digitized movie. The data can then be graphed and analyzed. (Laws & Pfister, 1998; PASCO.)

Visualizer[®]: Software that allows display of actual physical data and the output of analytic models in a 3-dimensional vector space, and the time evolution of vectors and trajectories. (Center for Science and Mathematics Teaching, Tufts University.)

Workshop Physics Tools (WPTools): Macros or *Excel[®]* “add-in tools” to enable users to create scatter plots or overlay graphs and do analytic modeling or curve fitting more easily. (Workshop Physics, Dickinson College.)

Members of the ABP Group also have extensive experience developing institutes, seminars and other professional development activities. In the past 16 years approximately 5500 physics teachers at the secondary school and college level have attended nearly 200 extended institutes or shorter workshops taught by Group members. Table 4 lists the extended (one week or longer) workshop series during this period for secondary teachers as part of national, sponsored projects.

TABLE 4: Physics /Physical Science Teacher Workshops by ABP Group Members

2000-2003 Activity Based Physics Institutes (NSF)—30 high school teachers at Oregon and Dickinson two weeks for two consecutive Summers 2000-01 and 2002-03.

1996-98 Summer Seminar: *Interactive Teaching Methods and Computers*(NSF)—30 high school teachers at Oregon (1998) and Dickinson (1996-97) for two weeks.

1993, 95, 97 Summer Outreach in Science (Howard Hughes Medical Institute)—30 high school science teachers at Oregon for two weeks each Summer.

1993-96 Student Oriented Science (U.S. Dept. of Ed.)—2-day academic year workshops and follow-ups for 24 high school teachers each year at Tufts, Oregon and Dickinson.

1988-92 Oregon Science Teaching: *Implementation and Research* (U.S. Dept. of Education--Eisenhower)—Monthly academic year (1988-90), and Summer (1990-92) workshops with follow-ups for 15 teachers each year at Oregon.

1989-90 LabNet (NSF)—20 teachers at two-week institutes held at Dickinson and Tufts each Summer.

1987-88 National Microcomputer-Based Laboratory Leadership Institutes (NSF)—Summer workshops held at Tufts University for 24 high school teachers.

Our experience with the challenges faced by many teachers suggests that a comprehensive approach is required to change their teaching strategies and epistemology. To be effective, teachers must first know how to *use* new technologies, and then how to *teach* using *Suite* materials. Teachers who are most successful with new, active learning approaches are those with a *deep understanding* of how to combine computer tools with effective teaching strategies. The experience gained in offering professional development workshops over the past 16 years has resulted in the recent publication of a second CD, the *Teacher Education Module* (available from Vernier Software and Technology) that addresses the needs of *teachers of teachers* who wish to implement computer-supported, activity-based workshops. The materials on this CD include suggestions, guidelines, specific curricular examples, and videos to guide workshop presenters.

A Model for Activity Based Teacher Professional Development

The ABP Group is committed to continue helping secondary physics and physical science teachers in grades 9-12 maximize their potential to improve their students' 1) functional understanding of concepts, 2) ability to solve problems, 3) ability to describe phenomena, 4) appreciation for the basis of scientific inquiry, and 5) use of computer-based laboratory tools for scientific investigation. What follows is a description of the most recent series of *Activity Based Physics Institutes* that were just completed in June, 2003, and the features that we believe promote the following primary institute goals:

- 1) To recruit qualified teachers seeking professional development in physics and physical science teaching and willing to adopt regional or national leadership roles, especially teachers of under-represented student populations, in rural school districts, empowerment zone schools and enterprise communities.
- 2) To educate teachers about the powerful role physics education research can play in curriculum development, classroom pedagogy, and assessment of student learning.
- 3) To familiarize teachers with the *Activity Based Physics Suite*, help them to adapt these materials to serve their classroom needs, and help them to meet local and national SMT standards.
- 4) To help teachers learn how to conduct action research in their classrooms so that they can appreciate the basis and rationale for the new pedagogical approaches, and improve the effectiveness of these new approaches in their classrooms.

- 5) To enable teachers to become educational leaders who can initiate local reform efforts in science education beyond their own classrooms.
- 6) To build and maintain a community of leader/researchers whose shared vision is aligned with physics education reform and responsive to national issues in science education.

To achieve these goals, the project had the following components, which have been refined over the years based on previous projects:

◆ *Activity Based Physics Institutes.* A total of 60 high school physics and physical science teachers were recruited nationally to participate in institutes at either at a West Coast site (University of Oregon in Eugene, OR) or an East Coast site (Dickinson College in Carlisle, PA) (30 at each site), and each received 160+ hours (four weeks) of professional development over two consecutive summers, 2000-01. The same program was repeated in 2002-03. This use of two sites has the following advantages:

- Lower participant travel expenses.

Increase in the applicant pool and diversity of participants.

More effective mentoring of participants by project staff.

Availability to the significant rural populations in close proximity to both sites.

Increase in regional collaboration after the institutes, since each site will attract at least some clusters of participants who are close enough to actively consult with each other.

More effective networking among cohorts of 30 teachers, rather than one cohort of 60.

Selected participants received a travel stipend that was adequate for most teachers in the continental U.S. to travel to the closest institute site. (We did have one participant from Hawaii, and one from American Samoa, but their travel was supplemented from school district or personal funds.) In addition, each participant was given an institute stipend if s/he attended both years of the program. While we desired to recruit teachers who already had the necessary classroom sets of computer-supported tools, we tried to assure that implementation was not impeded for participants who lacked these. Therefore, each applicant had to submit a signed statement of support from a local school or district administrator guaranteeing that a minimum of one specified complete set of computer, interface, probes and software would be available to the teacher. In this way, each teacher was assured to be able to implement at least *Interactive Lecture Demonstrations* in her/his classroom. We developed the *High School CD* and distributed it free of charge to the first cohort of participants (2000-01). For the second cohort (2002-03), a *High School CD* license was added to the list of required materials to be guaranteed locally. Having even the minimal set of equipment and software also has the synergistic effect that administrators can observe the efficacy of the resulting pedagogy, and many are then more willing to invest the funds necessary to purchase a complete set.

During the first week of the institutes, the focus was on direct experience working with the *Physics Suite* materials contained on the *High School CD*, and examining the pedagogy made possible with computer-based curricula and tools. The main topics were mechanics and electric circuits. In these sessions, we asked the teachers to actually work through the activities in the curricula as their students would. Only in this way can participants really appreciate the significant pedagogical changes in our approach to learning. As much as possible, the equipment and computer tools were set up by the institute staff in order to keep the focus of the institute on pedagogy using technology *not the technology itself*. While improving content knowledge was not a primary institute goal, our pre-testing

of participants using conceptual evaluations we have developed (for example, Thornton & Sokoloff, 1998), suggest that some participants were in need of such remedial work. An incidental result of teachers working carefully through the materials is that they learn the concepts.

The second week's focus was 1) completing a curriculum project that adapts the materials to each individual teacher's local needs, 2) learning how to conduct action research in the classroom, and 3) developing leadership and community-building skills. Appendix A includes the complete schedule of the Summer, 2002 Institute. Participants' thoughts on the institute experience were collected every few days through reflections recorded on *Blackboard*. This provided formative feedback for the institute staff to adjust institute features, and also has provided valuable information for the summative evaluation of the project.

The overall structure of the second summer institute for each cohort was similar. There were, however, four significant differences:

- 1) The emphasis was on different physics topics, heat and temperature, energy, waves and sound and optics.
 - 2) Sharing sessions were scheduled so that each returning participant could report on her/his experiences implementing active learning and disseminating to colleagues during the previous school year.
 - 3) Participants were given more responsibility for setting up the equipment and software, to help them work out any problems they may have had, and to build more confidence. (This is important, since most high school teachers in the U.S. do not have much technical support in their schools.)
 - 4) Instead of working on a curriculum implementation project during the second week, participants were encouraged to do a capstone project on energy that incorporated much from the energy and heat and thermodynamics units that they worked on the first week.
- ♦ *Follow-up and Cohesion Activities.* An Activity Based Physics web-site and a listserv were used to facilitate correspondence. These were used initially to handle technical problems that participants had with implementation. As the project progressed, more teachers used the listserv to report on classroom successes, successes in getting grants and other funding and local workshops and other dissemination activities.

The following outcomes were a result of this professional development model:

- 1) 120 secondary physics and physical science teachers had training in using curricular materials in the *Activity Based Physics Suite* and in the implementation of pedagogy based on the outcomes of physics education research. They were enabled to have immediate experience implementing the materials and classroom strategies through a requirement of local support.
- 2) Based on their testimonies, many of these teachers have implemented active learning with the available tools, and have significantly changed their pedagogy.
- 3) Many teachers have conducted action research and/or taken leadership roles in their school districts for recruiting and mentoring other physics and physical science teachers.

How Successful Was this Model?

The pre-institute attitudes and teaching strategies of the 120 institute participants have already been assessed. However, the summative evaluation of these recently completed *Activity Based Physics*

Institutes is not yet available. (A detailed longitudinal study of attitudinal and behavioral changes effected by participants' institute experiences is being conducted by Dr. James Hoefler of Dickinson College. In addition, Maxine Willis, one of the Institute instructors will be studying the effectiveness using classroom visits and interviews, as part of her sabbatical leave project in 2004-2005.) Anecdotal evidence, based on communications on the listserv and participants' presentations during the Summer, 2001 and 2003 sharing sessions, indicates a high degree of implementation of more active approaches, with many teachers using a subset of the *Physics Suite* materials. We do have formal summative evaluations of our previous institute programs, on which the most recent series was based, that document a remarkable degree of change in the participants. For example, there is a detailed evaluation report of our Summer Seminar series (1990-96) written by Dr. Hoefler. This series had many of the same features, except that the institutes were only of one summer duration (80+ hours of instruction.). Approximately 230 college and high school teachers attended during this period. In a survey designed by Dr. Hoefler (Hoefler, 1998) to evaluate the impact of the seminars on the participants, the 92 respondents indicated that as a result of the institutes:

81% were *optimistic* about the value of the new approaches

66% devoted less time to lecturing, and more time to activity-based learning

Based on the survey responses, the seminar series impacted 84,000 students between 1990 and 1997.

Conceptual learning had improved for over half of their students, and 62% of their students reported enjoying the new methods better than old approaches

They disseminated activity-based methods via direct contact with a total of 430 colleagues inside and outside of their institutions. Additionally, 31% of the respondents reported spreading the word by means of presentations and workshops.

Three quarters applied for a total of \$4.6 million and received \$3.3 million to implement these methods.

Only 60% of respondents submitted written suggestions for *improving* the seminars, and nearly half of these ended up writing, "change nothing."

The executive summary of the report concludes that the "...seminars are viewed in a very positive light by an overwhelming majority of the seminar alumni who took part in this study."

We believe that one reason for our successes in changing teachers' classroom practice is the post-institute communication mechanisms (support of classroom action research, web-site, listserv, e-mail, informal mentoring at national AAPT meetings) that we have incorporated into all of our institute programs. Two of the high school teachers currently in our ABP Group, Maxine Willis and John Garrett are fine examples of the transformations that are possible. (There are many other examples of participants who have changed their pedagogy significantly.) Willis and Garrett have emerged as outstanding teachers and teacher leaders by coupling motivation and professional maturity with strong mentoring from the college/university ABP Group members in their geographical areas. Their contributions to the work of the ABP Group continue to improve and expand all areas of curriculum development, training and dissemination, and, their active involvement enhances the Group's credibility with high school teachers.

The Next Step, Research on Professional Development

While there is considerable evidence for the success of this institute model, we are aware of its shortcomings. In addition, many concerns are found in recent literature about research and

instructional improvement (Feldman & Minstrell, 2000). Some of these concerns provide a basis for the following research questions:

- 1) What motivates teachers to want to investigate what works with their students, and in what ways do these investigations lead teachers to become better constructivist educators?
- 2) What are the group dynamics for teams of researchers with ABP Group facilitation? Which social configurations work best: dyads, triads, larger groups, and how do these groups function in a “virtual community” over the internet?
- 3) The ABP Group is comprised of 4-year college faculty, university faculty, and high school teachers. How do their backgrounds, personalities, learning and teaching perspectives, and immediate commitments determine their ability to succeed in a mentoring role, especially with regard to teacher-initiated action research? Specifically, how do curriculum developers and workshop leaders transform into research team leaders and mentors, and can (or should) they sustain this role for years as described by Feldman (1998)?
- 4) How do factors such as varying levels of physics understanding, technical expertise, pedagogical skill, social skills, educational research skills, classroom rapport, among others, influence success as ABP teachers and researchers?
- 5) How do the workshop leaders become transformed in their practice as a consequence of working with teacher research teams?

We are currently planning a new series of institutes which will have a greater focus on researching the model. These are a few of the questions that will be investigated in this project, but we expect many more issues to arise during the institutes, follow-up and mentoring activities. If the project is funded, the new series will return to a one-summer model, and will incorporate these additional features:

- ◆ *Equipment Loan Program.* We will purchase 5 complete classroom sets of computer interfaces, probes and software for each institute site, and establish a loan program for these instructional materials. This will enable as many as one half of the participants to borrow these materials for at least one half of the school year. In addition, we will supply copies of the *High School CD* to teachers whose schools do not own a license. Our experiences from the past institute programs in which we made computer-based tools available on loan suggest that a significant number of the participants who borrow the tools will be able to convince their schools or districts to purchase them. This will significantly increase the availability and potential impact of the loaned tools over the duration of the project.
- ◆ *Additional Second Week Focuses.* The second week's focus will be 1) completing a curriculum project that adapts the materials to each individual teacher's local needs, 2) learning how to conduct action research in the classroom, 3) developing leadership and community-building skills, 4) participating in sessions on educational research methodology, and 5) forming research teams.
- ◆ *Follow-up Leadership Meetings.* Beginning the second Summer, two follow-up options will be available to participants: three-day meetings at the institute sites and/or reunions at national AAPT meetings. At the three-day meetings, participants will share their classroom experiences integrating the new teaching strategies and tools. The sharing can take place during the 1-day overlap when the new recruits will have an afternoon and evening with the veterans prior to the start of the institute. They will also receive additional leadership training skills to help them serve as change agents for other teachers in their regions, and they will meet in their research teams. Participants will be encouraged to bring a colleague who will participate in the immediately

following 2-week Summer institute. Similar sharing, mentoring and research team meetings will take place at the AAPT reunions.

- ◆ *Research Study on Our Professional Development Model.* Participating teachers will be tracked for the duration of the grant, to examine in detail the effectiveness of this professional development model in changing their pedagogy and epistemology. The research teams will study the issues that determine the success or failure of in-service professional development. The impact on teachers will also be compared to that for the professional development model used in our most recent series of *Activity-Based Physics Institutes*. Additional essential research will take place through mentoring the research teams. WebCT or Blackboard will facilitate communication among these groups. The research results will be disseminated broadly to those in both science disciplines and in education involved in the preparation and enhancement of teachers.

This project will also build upon our knowledge from previous institutes. The research questions pursued will be informed and refined by the summative evaluation activities from the previous project. Also, in addition to exploring changes in participants' pedagogy and epistemology effected by their institute experiences, the availability of previous summative data will allow us to study three significant practical aspects of our professional development model:

- 1) In terms of the eventual impact on students, is it more cost-effective to provide 160+ hours of instruction to a group of teachers, or half as many hours of instruction to twice as many teachers? We will answer this question by comparing the two-summer institute model in the *Activity Based Physics Institutes* we have just completed to the one-summer model in this project.
- 2) Will developing a mentoring relationship with participants, and bringing them back together for reunions at subsequent institutes and/or at national AAPT meetings be as effective in establishing and supporting the leadership and dissemination roles as having a full two-week follow-up session in the following summer, as in the *Activity Based Physics Institutes* we have just completed?
- 3) Will the availability of computer-based interfaces and probes on loan from the project to teachers who do not yet have these available to them in their schools increase the effectiveness of the institutes in bringing about pedagogical changes and more effective use of computer-supported curricula in their classrooms? Will the availability of the loaned computer-based tools increase the chance that teachers' schools and/or districts will make permanent purchases of them?

Conclusions

Carefully designed, comprehensive professional development programs can effect significant pedagogical and epistemological changes while introducing secondary teachers to activity based curricula supported by computer-based tools. Important features include 1) study of the research base for the new pedagogical approaches, 2) intensive experience with the curricula and tools, 3) institute time to plan adaptation to individual classroom needs, 4) local action classroom research on student learning, 5) availability of the curricula tools and 6) formal follow-up activities. However, there is still much to be researched about the features that determine the success or failure of these programs.

References Cited

Beatty, B. R. (1999, April 19-23). *Teachers Leading Their Own Professional Growth: Self-Directed Reflection and Collaboration and Changes in Perception of Self and Work in Secondary School Teachers*. Presented at the Annual Meeting of the American Educational Research Association, Montreal, Quebec, Canada.

- Camp, C., Clement, J., Brown, D., Gonzalez, K., Kudukey, J., Minstrell, J., Schultz, K., Steinberg, M., Veneman, V., and Zietsman, A. (1994). *Preconceptions in mechanics: Lessons designed to deal with student's conceptual difficulties*. Dubuque, IA: Kendall/Hunt.
- Center for Science and Mathematics Teaching, Tufts University. <http://ase.tufts.edu/csmt>.
- Cummings, K., Laws, P.W., Redish, E.F. and Cooney, P.J. (2004). *Understanding Physics*. New York, John Wiley & Sons.
- Feldman, A. (1996). "Enhancing the practice of physics teachers: Mechanisms for the generation and sharing of knowledge and understanding in collaborative action research." *Journal of Research in Science Teaching*, 33(5). 513-540.
- Feldman, A. (1998). "Implementing and assessing the power of conversation in the teaching of action research." *Teacher Education Quarterly*, 25(2), 27-42.
- Feldman, A. & Minstrell, J. (2000). "Action Research as a Research Methodology for the Study of the Teaching and Learning of Science." In Anthony E. Kelly & Richard A. Lesh (Eds.), *Handbook of Research Design in Mathematics and Science Education* (pp. 429-455). Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Hake, R.R. (1998). "Interactive-engagement versus traditional methods: A six-thousand student survey of mechanics test data for introductory physics courses," *Am. J. Phys.* **66**, 64-74.
- Halloun, I.A. and Hestenes, D. (1985). "The initial knowledge state of college physics students," and "Common sense concepts about motion," I. A. , *Am. J. Phys.* **53**, 1043-1065.
- Hammerman, J. K. (1995). "Teacher Inquiry Groups: Collaborative Explorations of Changing Practice." In Barbara Scott Nelson (Ed.), *Inquiry and the Development of Teaching: Issues in the Transformation of Mathematics Teaching. Center for the Development of Teaching Paper Series* (pp. 47-56). Newton, MA: Center for Development of Teaching, Education Development Center, Inc.
- Hoefler, J. M. (1998). *Dickinson Summer Seminars Program Evaluation for 1990-1997*. http://physics.dickinson.edu/~wp_web/wp_resources/wp_evaluation.html.
- Jackson, D.P., Laws, P.W. and Franklin, S.V. (2002). *Explorations in Physics*. New York, John Wiley & Sons.
- Laws, P.W. (December, 1991). "Calculus-based physics without lectures," *Phys. Today* **44**, (12), 24-31.
- Laws, P.W. (1997(1)). *Workshop Physics Activity Guide, Modules 1-4 w/ Appendices*. New York, John Wiley & Sons.
- Laws, P.W. (1997 (2)). "Millikan Lecture 1996: Promoting active learning based on physics education research in introductory physics courses," *Am. J. Phys.* **65**, 14-21.
- Laws, P.W. and Pfister, H. (1998). "Using digital video analysis in introductory mechanics projects," *The Physics Teacher* **36**, 282-287.
- Martin-Kniep, G. O., Sussman, E. S., & Meltzer, E. (1995, Fall). The North Shore Collaborative Inquiry Project: A Reflective Study of Assessment and Learning. *Journal of Staff Development*, 16(4), 46-51.
- McDermott, L.C. (1991). "Millikan Lecture 1990: What we teach and what is learned--Closing the gap," *Am. J. Phys.* **59**, 301-315.
- McDermott, L.C. and the Physics Education Group at the University of Washington. (1996). *Physics by Inquiry*. New York, John Wiley & Sons.

- McDermott, L.C. Shaffer, P.S. and Vokos, S. (1997(1)). "Sample course on *Physics by Inquiry*." In *The Changing Role of Physics Departments in Modern Universities: Proceedings of the International Conference on Undergraduate Physics Education*, University of Maryland, College Park, 1997, edited by E.F. Redish and J. Rigden, pp. 989-1005. Woodbury, NY, American Institute of Physics.
- McDermott, L.C. Shaffer, P.S. and Vokos, S. (1997(2)). "Sample course on *Tutorials in Introductory Physics*." In *The Changing Role of Physics Departments in Modern Universities: Proceedings of the International Conference on Undergraduate Physics Education*, University of Maryland, College Park, 1997, edited by E.F. Redish and J. Rigden, pp. 1007-1018. Woodbury, NY, American Institute of Physics.
- McDermott, L.C. and Redish, E.F. (1999). "Resource Letter PER-1: Physics Education Research," *Am. J. Phys.* **67**, 755-767.
- McDermott, L.C., Shaffer, P.S. and the Physics Education Group at the University of Washington. (2002). *Tutorials in Introductory Physics*, First Edition. Upper Saddle River, NJ, Prentice-Hall.
- PASCO Scientific, <http://www.pasco.com>.
- Redish, E.F., Saul, J.M. and Steinberg, R.N. (1997). "On the effectiveness of active-engagement microcomputer-based laboratories," *Am. J. Phys.* **65**, 45-54.
- Redish, E.F. (2003). *Teaching Physics with the Physics Suite*. New York, Wiley.
- Schifter, D. L., and Fosnot, C. T. (1993). *Restructuring mathematics education: Stories of teachers meeting the challenge of reform*. New York, NY: Teachers College Press.
- Sokoloff, D.R. and Thornton, R.K. (1992). *Tools for Scientific Thinking--Motion and Force Curriculum and Teachers' Guide. Second edition*. Portland, Vernier Software.
- Sokoloff, D.R. and Thornton, R.K. (1997). "Using interactive lecture demonstrations to create an active learning environment," *The Physics Teacher*, Vol. 35, pp. 340-346.
- Sokoloff, D.R., Laws, P.L. and Thornton, R.K. (1998 (1)). *RealTime Physics Module 1: Mechanics*. New York, John Wiley & Sons.
- Sokoloff, D.R., Laws, P.L. and Thornton, R.K. (1998 (2)). *RealTime Physics Module 2: Heat and Thermodynamics*. New York, John Wiley & Sons.
- Sokoloff, D.R., Laws, P.L. and Thornton, R.K. (2000). *RealTime Physics Module 3: Electric Circuits*. New York, John Wiley & Sons.
- Sokoloff, D.R. and Thornton, R.K. (2004). *Interactive Lecture Demonstrations in Introductory Physics*. New York, John Wiley & Sons.
- Sokoloff, D.R., Laws, P.L. and Thornton, R.K. (2004). *RealTime Physics Module 1: Mechanics, Module 2: Heat and Thermodynamics, Module 3: Electric Circuits, Module 4: Light and Optics*. New York, John Wiley & Sons.
- Thornton, R.K. and Sokoloff, D.R. (1990). "Learning motion concepts using real-time microcomputer-based laboratory tools," *Am. J. Phys.* **58**, 858-867.
- Thornton, R.K. and Sokoloff, D.R. (1993). *Tools for Scientific Thinking--Heat and Temperature Curriculum and Teachers' Guide*. Portland, Vernier Software.
- Thornton, R. K. (1996). "Using large-scale classroom research to study student conceptual learning in mechanics and to develop new approaches to learning." In *Microcomputer-Based Laboratories*:

Educational Research and Standards, Series F, Computer and Systems Sciences, Vol. 156, Robert F. Tinker, ed. Berlin, Heidelberg, Springer Verlag, pp. 89-114.

Thornton, R.K. (1997) "Learning physics concepts in the introductory course: Microcomputer-based labs and interactive lecture demonstrations." In *Conference on the Introductory Physics Course*, J.W. Wilson, ed. New York, John Wiley & Sons, pp. 69-85.

Thornton, R.K. and Sokoloff, D.R. (1997). "RealTime Physics: Active Learning Laboratory." In *The Changing Role of Physics Departments in Modern Universities: Proceedings of the International Conference on Undergraduate Physics Education*, University of Maryland, College Park, 1997, edited by E.F. Redish and J. Rigden, pp. 1101-1118. Woodbury, NY, American Institute of Physics.

Thornton, R.K. and Sokoloff, D.R. (1998). "Assessing student learning of Newton's laws: The force and motion conceptual evaluation," *Am. J. Phys.* **58**, 858-867.

Thornton, R.K. and Sokoloff, D.R. (1999). *Microcomputer-Based Interactive Lecture Demonstrations (ILDs) in Force, Motion and Energy with Teachers' Guide*. Portland, Vernier Software.

Vernier Software and Technology. <http://www.vernier.com>.

Workshop Physics, Dickinson College. http://physics.dickinson.edu/~wp_web/WP_homepage.html.

APPENDIX A
ACTIVITY BASED PHYSICS INSTITUTE SCHEDULE
SESSION I: June 16-28, 2002

Each day during the first week has 4 blocks of 90 minutes each.
Breaks are held at 9:50 AM and 2:30 PM. Lunch is 11:40 AM - 1:00 PM.

Block 1 is 8:20 to 9:50 am	Block 3 is 1:00 to 2:30pm
Block 2 is 10:10 to 11:40pm	Block 4 is 2:50 to 4:20pm

WEEK ONE

SUNDAY, JUNE 16

6:00-9:00 PM Welcome Picnic and Introductions

MONDAY, JUNE 17

BLOCK 1: INTRO TO INSTITUTE CURRICULUM/CONCEPTUAL EVALUATION I

- 1) Overview of Institute Curriculum (15 min)
- 2) Plenary Discussion on Research Basis of FMCE and ECCE (30 min)
- 3) Complete the FMCE (45 min)

BLOCKS 2-3: KINEMATICS CONCEPTS w/ TST & RTP

- 1) Overview Discussion (15 min)
- 2) Key Technical Points (5 min)
- 3) Guided Inquiry: TST Labs 1 & 2 (140 min)
- 4) Guided Inquiry: TST Lab 1 & Lab 2 (140 min)
- 5) Discussion: How does this differ from traditional instruction? (20 min)

BLOCK 4: CONCEPTUAL EVALUATION II/INTRO TO BLACKBOARD

- 1) Plenary session to compare predictions w/data on student performance and their own pretest data (30 min)
- 2) Introduction to Blackboard: Pictures and Profiles (60 min)

5:00 PM Pre-dinner Social

6:30-8:30 PM Open Labs for MBL Practice and Reflections (Instructor will be on hand)

TUESDAY, JUNE 18

BLOCKS 1-2 MODELING & MATHEMATICS FOR CONSTANT ACCELERATION

- 1) Overview Discussion (15 min)
- 2) Key Technical Points (5 min)
- 3) Modeling w/ WP Activities 1.6-1.7 (**w/ HW**), 4.6 (**as demo**), 4.7 (**as hands-on**) (130 min)
- 4) Mini-project on modeling: Fan carts w/ different thrusts using VideoPoint (20 min)
- 5) Sharing Outcomes of Mini-project (10 min)

BLOCK 3: MEASUREMENT AND UNCERTAINTY I (WP Unit 2)

- 1) Overview Discussion (15 min)
- 2) Key Technical Points (5 min)
- 3) Guided Inquiry: WP Activities 2.2–2.8 (70 min)

BLOCK 4: MEASUREMENT AND UNCERTAINTY II

- 1) Guided Inquiry (continued): WP Activities 2.2–2.8 (40 min)
- 2) Mini-project: Indirect Measurement of Height (30 min)
- 3) Sharing Outcomes of Mini-project (10 min)
- 4) Discussion: Compare and contrast w/traditional instruction and TST (10)
- 5) 6:30-8:30 PM Open Labs for MBL Practice and Reflections (Instructor will be on hand)

WEDNESDAY, JUNE 19

BLOCK 1: FORCE & MOTION I

Guided Inquiry: RTP Lab 3 Act 2-1 through 2-5 (90 min)

BLOCK 2: FORCE & MOTION II

- 1) Guided Inquiry: RTP Lab 4 Activities 1-1 and 1-2, Activity 3-1 (60 min)
- 2) Mix and match RTP Extensions (20 min)
- 3) Sharing outcomes of Extensions (10 min)

BLOCK 3: FORCE & MOTION III

Guided Inquiry: RTP Lab 5 Activities 1-1 through 2-2 (90 min)

BLOCK 4: FORCE AND MOTION WRAPUP/INTRODUCTION TO HSCD

- 1) Overview Discussion on New Mechanics Sequence (20 min)
- 2) Discussion: Compare and contrast RTP w/other teaching methods (10 minutes)
- 3) Introduction to HSCD materials and practice with browser (60 minutes)

6:30-8:30 PM Session this evening on Videocapture and Visualizer and DYNA.
Time to be decided.

THURSDAY, JUNE 20

BLOCKS 1-2: INTERACTIVE LECTURE DEMO PREPARATION/ DELIVERY

- 1) ILD Overview: Newton's 1st, 2nd, and 3rd Laws with ILDs (60 min)
- 2) Formation of 4 teams of 7-8 people and ILD segment selections (20 min)
- 3) ILD Preparation by Teams (100 min)

BLOCK 3: INTERACTIVE LECTURE DEMONSTRATION DELIVERY (90 min)

BLOCK 4: ILD WRAPUP

- 1) Completion of ILD delivery (60 min)
- 2) ILD Wrap Up: Discussion of common delivery problems (20 min)
- 3) Discussion: Compare and contrast ILDs w/other teaching methods (10 min)

5:00 PM Barbeque .

FRIDAY, JUNE 21

BLOCKS 1-2: ELECTRICITY I: Selected RTP activities

- 1) Overview Discussion (15 min)
- 2) Key Technical Points (5 min)
- 3) Guided Inquiry (200 min)

BLOCKS 3-4: ELECTRICITY II: Selected WP activities

- 1) Overview Discussion (15 min)
- 2) Key Technical Points (5 min)
- 3) Guided Inquiry (140 min)
- 4) Brainstorming on Week Two Activities (20 min)

WEEK TWO

MONDAY, JUNE 24

BLOCK 1: PROJECT PLANNING (EQUIPMENT & FACILITIES) (60 min)

BLOCK 2: SHARATHON (200 min)

BLOCKS 3-4: PROJECT WORK

TUESDAY, JUNE 25

BLOCK 1: ASSESSMENT: IMPLEMENTING ACTION RESEARCH

BLOCKS 2-4: PROJECT WORK

WEDNESDAY, JUNE 26

BLOCK 1: 2D FORCE AND MOTION Workshop Physics 6.6 through 6.11

BLOCK 2-4: PROJECT WORK

THURSDAY, JUNE 27

BLOCK 1: KINEMATICS PROBLEM SOLVING (COLLABORATIVE)

- 1) Overview discussion (15 min)
- 2) Key technical points for collaborative problem solving (5 min)
- 3) WP Activities 4.8, 4.9 or Challenge problems w/Morse Worksheets (50 min)
- 4) Discussion (20 min)

BLOCK 2: PROJECT WORK

BLOCKS 3-4: PROJECT PRESENTATIONS I (180 min)

Participants will speak (10 min each)

FRIDAY, JUNE 28

BLOCKS 1-2: PROJECT PRESENTATIONS I (120 min)

- 1) Participants will speak (10 min each)
- 2) Wrap up discussion on most effective forms of school year support (20 min)

12:00 Noon Buffet Lunch (Willamette Hall Atrium)