# A Call to the AAPT Executive Board and Publications Committee to Expand Publication of Physics Education Research Articles within the American Journal of Physics


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***Summary:*** *The recent dramatic expansion of activity in physics education research among AAPT members has not been matched by commensurate increases in publication venues. Although the impact of this research field within the broader physics community has sharply increased, the viability of its continued existence is dependent upon substantially expanded publication opportunities in the near future. The American Journal of Physics has served for three decades as the primary publication venue for results in physics education research. An increased number of pages devoted to physics education research is consistent both with AJP's historical role and with the greater prominence in recent years of the PER community within AAPT. We recommend (1) considering PER submissions to the main section of AJP on a par with submissions in other subject areas, (2) increasing the number of pages allocated to the PER Section, and (3) allowing the option of increasing the publication frequency of the PER Section from its present rate.*

**Introduction:** Evaluating and improving the teaching and learning of physics is a prime concern for a large proportion of all physicists, and is the central focus of the AAPT. Significant numbers of physicists have begun to apply to the problems involved in teaching and learning physics the same systematic methods of research and analysis they have employed so successfully in investigating the physical world. They have carried out detailed, systematic, and reproducible studies involving the collection and analysis of data reflecting student thinking and performance. This endeavor, broadly known by the term "physics education research" (PER), has in recent years undergone rapid expansion both in the numbers of physicists involved, and in the recognition and impact of its results within the broader physics community.

**The role of physics education research in advancing the teaching of physics:** The role of PER within AAPT is perhaps best understood by examining the goals of AAPT itself. The AAPT Mission Statement, posted on the AAPT home page [http://www.aapt.org/aboutaapt/mission.cfm], stresses that it is "*committed to providing the most current resources and up-to-date research needed to enhance a physics educator's professional development*." The Mission Statement continues: "*The Association has identified four critical issues that will guide our future activities,*" among which it includes the following: "*#3: Improve the pedagogical skills and physics knowledge of teachers at all levels; #4: Increase our understanding of physics learning and of ways to improve teaching effectiveness.*" Physics education research is devoted to achieving precisely these objectives.

The goal of physicists working in PER is, broadly speaking, to increase the effectiveness and efficiency of physics education at all levels, from the pre-secondary level up to the graduate level, and for the public in non-academic settings. In recent years, PER has had a dramatic impact on the way in which physics is taught, on the ways in which many physics educators view the issues involved in their profession, and in the preparation of physics teachers at both the high-school and university level. The published findings of physics education research, based on rigorous and reproducible testing and measurement, have disclosed heretofore unknown or under-appreciated aspects of the traditional process of physics education. Research has revealed the broad gap that often exists between the objectives physics instructors have for their courses, and the actual level of conceptual understanding attained by most students engaged in traditional forms of instruction. Ongoing research has clarified the dynamics of student thinking during the process of learning physics, revealing both particular learning difficulties, as well as effective strategies for guiding student insight and understanding. Based directly or indirectly on this research, many new forms of curricular materials and instructional methods have been developed and disseminated throughout the nation and the world. Countless reports have documented improved learning gains resulting from the use of research-based curricula and instructional methods.

The results of research and of research-based instructional methods have thrust the concept of "active engagement" or inquiry-based learning into the forefront of the entire physics education community. Led by workers in PER, innumerable studies have demonstrated the effectiveness of forms of instruction that supplement (in some cases, replace) traditional lecture-based methods with inquiry-based learning based on cooperative groups. Students are guided to work their way through carefully designed and tested sequences of questions, exercises, and/or laboratory activities. Utilizing these research-based curricula, and interacting frequently during class with instructors and with each other, students have often achieved significant gains in understanding when compared with instruction based on lecture alone. By basing the design of curricula and instructional methods on the results of physics education research, and by subjecting them to repeated testing, evaluation, and re-design, dramatic learning gains have been made in physics courses of all types, from large-enrollment classes at huge public universities to small-group laboratory courses in junior colleges and high-school classrooms. Many workshops involving hundreds of new college and university faculty members have been held by AAPT in which the new forms of research-based instruction have been placed at the forefront, and PER researchers have led the majority of plenary sessions.

Due in significant part to the efforts of the physics education research community over the past 20 years, the field of physics education is enjoying a heretofore unknown degree of growth and prominence at all levels, from the elementary and middle schools, through high schools, junior colleges, four-year colleges, and universities. The rapid influx of new participants into the PER community, now occurring to an extent never seen before, offers the promise of additional dramatic advances in physics education in the future based on and guided by new research findings. The degree to which this dynamic expansion in impact and outreach can be sustained will depend, in large part, on the well-being and growth of the physics education research community itself. As is true for any research field, a central issue for the PER community is the effectiveness and flexibility of its means for documentation and dissemination of research results – that is, its form of publication. For the field of PER over the past few decades, the American Journal of Physics has been the central link between researchers in physics education, and the broader community of physics educators worldwide.

In order to implement AAPT's mission of providing the most up-to-date research needed by physics educators, and of increasing our understanding of physics learning and of ways to improve teaching effectiveness, some form of archival record is needed. Only such a record can ensure wide and continuing dissemination of the results obtained by workers in physics education, and can serve as a basis on which to build future advances. The unique tool available to the AAPT for providing this archival record has been and continues to be the American Journal of Physics.

**The place of PER within the American Journal of Physics:** In a recent editorial introducing the PER section in the American Journal of Physics, some specific criteria were given to characterize research papers in PER:

> Articles . . . are expected to focus more on questions of not only what we think we know about student learning, but how we know and why we believe what we think we know. Articles in PERS can be expected to address a wide range of topics from theoretical frameworks for analyzing student thinking to developments of research instruments for the assessment of the effectiveness of instruction and to the development and comparison of

> different teaching methods. Articles should include careful discussions of research methodology and how the work was done.[1]

A somewhat broader characterization of PER was given by the editor of the PER Supplement to AJP (introduced in 1999 and merged into AJP itself as a special section in 2002):

> It focuses on using the methods and culture of science to help us understand how students learn physics and how to make our instruction more effective. By the methods of science, I mean careful observation and analysis of the phenomenon under study. By the culture of science, I mean documenting and publishing research to evaluate and critique the work for the purpose of building a community consensus of what we know.[2]

It is important to recognize that research falling under the broad definition of PER has been carried out and published not only recently, but rather for several decades. For over 30 years, the primary means of documentation of physics education research and of communicating its results to the worldwide physics community has been the American Journal of Physics. More than 120 papers describing the methods and results of research into physics learning were published in AJP from 1972 to 1998.[3] An approximate breakdown of these papers is as follows: 1972-1979: 35 papers (4.4 per year; range: 1-8 per year); 1980-1989: 38 (3.8 per year; range: 0-9 per year); 1990-1998: 54 papers (6.0 papers per year; range: 3-9 per year). Some of these early papers are listed in Appendix A.

Although the official policy of AJP has always been that it is not a "research journal," actual editorial practice has long acknowledged, in effect, that the exclusion of research papers adopted by the journal's founders was aimed at research in the traditional subfields of physics (nuclear, high-energy, condensed matter, etc.). As is demonstrated by the figures cited above, papers devoted to research investigations in the teaching and learning of physics have been *continuously* published in AJP for over three decades. Many of these papers (including dozens published before 1999) incorporate extensive data tables, complex methodologies for data collection and analysis, and lengthy discussions of methods and results. These features are characteristic of papers published in archival physics research journals, and demonstrate that it has long been considered appropriate for AJP papers devoted to physics education research to adopt the format and style of research papers in traditional physics areas. (Such papers occasionally may be viewed as less readily accessible to an ordinary physics teacher "practitioner." However, this is surely no different from the similarly limited accessibility of many highly specialized papers currently published in AJP, often readable only by physicists with advanced-level training in very specific areas.)

In fact, the American Journal of Physics has long served as the dominant English-language forum for publication of investigations carried out by physicists that focus on research into teaching and learning of physics at the college and university level. Certainly there are other journals in which research regarding physics teaching and learning is and has been reported. However, most of these journals are primarily devoted to research carried out by non-physicists in broad areas of science instruction at the pre-college level, and they have extremely limited readership among physics instructors at the post-secondary level. By any measure, the circulation, readership, and recognition of the American Journal of Physics among the university physics community is *overwhelmingly* greater than any comparable publication.

**The role of PER within the physics community:** The reality of AJP's dominant role has in recent years taken on increased significance as the size and impact of the physics education research community has grown. A very important indication of this increased impact was the May 21, 1999 statement by the Council of the American Physical Society:

99.2 RESEARCH IN PHYSICS EDUCATION

(Adopted by the Council, 21 May 1999)

In recent years, physics education research has emerged as a topic of research within physics departments. This type of research is pursued in physics departments at several leading graduate and research institutions, it has attracted funding from major governmental agencies, it is both objective and experimental, it is developing and has developed publication and dissemination mechanisms, and Ph.D. students trained in the area are recruited to establish new programs. Physics education research can and should be subject to the same criteria for evaluation (papers published, grants, etc.) as research in other fields of physics. The outcome of this research will improve the methodology of teaching and teaching evaluation.

The APS applauds and supports the acceptance in physics departments of research in physics education. Much of the work done in this field is very specific to the teaching of physics and deals with the unique needs and demands of particular physics courses and the appropriate use of technology in those courses. The successful adaptation of physics education research to improve the state of teaching in any physics department requires close contact between the physics education researchers and the more traditional researchers who are also teachers. The APS recognizes that the success and usefulness of physics education research is greatly enhanced by its presence in the physics department.[4]

In fact, as this statement suggests, the growth of physics education research as a research subfield within U.S. physics departments has been extraordinarily rapid over the past six years. There has been approximately a fourfold expansion in the number of physics departments that now include among their faculty one or more members whose scholarly efforts are devoted primarily or entirely to work in physics education. More than fifty tenure-track faculty positions in the U.S. have been filled during this period by physics education researchers,[5] with almost all of these at the junior-faculty level. At least 30 Ph.D.-granting physics departments now include tenured or tenure-track PER faculty, most of whom are guiding (or preparing to guide) graduate students toward Masters or Ph.D. degrees in physics education research.[6]

The explosion of interest and participation in physics education research has also been dramatically apparent at the national meetings of the AAPT. For most of the past decade, sessions devoted to PER papers have routinely been filled to overflowing, and increasingly large proportions of both invited and contributed presentations at AAPT meetings have been devoted to physics education research. Ever more workshops are being sponsored by the Research in Physics Education committee. Attendance at the annual Physics Education Research Conference – extending an extra day beyond the end of the summer AAPT meeting – has now nearly reached 200 physicists.

**The current status of publication outlets for PER:** In startling contrast to the rapid growth of activity in physics education research, the availability of publication venues has not kept pace. A PER Supplement to AJP began publication in 1999 and has recently transformed into a separate, twice-yearly section within AJP itself. Although we have made some progress since the early years (see next paragraph), the growth has been modest and it is clear that there is increasing demand. Further, the hiring patterns described above suggest that we need to be prepared to respond quickly and effectively to increasing demand.

The number of PER papers published in AJP since 1999 is as follows: ***1999***: main section, 9; PER Supplement, 8; ***2000***: main section, 0; PER Supplement, 7; ***2001***: main section, 6; PER Supplement, 6; ***2002***: main section, 7; PER Section, 7; ***2003***: main section, 3; PER Section, 4; ***2004***: main section, 0; PER Section, 2. The average number of PER papers in the main section of AJP is now actually *lower* than typical rates from earlier years.

This is not due to a lack of publishable work; rather, the artificial limitation on the number of pages allowed for PER papers in AJP has itself served to constrain the efforts of researchers within the field. The increasingly long backlog-induced delays for the PER Section – now at approximately two years – and the impression that PER papers appear only infrequently within the main section of AJP, have in some cases led researchers to delay writing and submitting mature research results that had already been widely disseminated through other means such as invited and contributed presentations, workshops, web sites, etc. Often, the only practical and rapid publication option for researchers has been to submit short summary reports of their work to the annual *Proceedings* of the Physics Education Research Conference.

The rapid increase in number of submissions to the *Proceedings* (47 papers were submitted to this year's edition) is evidence of the pent-up demand within the PER community for publication venues. However, the extremely limited circulation of the *Proceedings* (now and for the foreseeable future) implies both a much-lessened impact for this work within the broader physics community, as well as uncertain acceptance by departmental tenure and promotion committees upon whose decisions the continued employment of PER researchers depends. In many research-oriented departments, *Proceedings* papers are not counted as being on a par with publication in established journals, and in some departments they may not count at all.

Very recently the possibility has arisen of an electronic publication venue coming into existence based on limited-term funding from the National Science Foundation. This electronic journal forms one component of the PER-CENTRAL project (Community Enhancing Network for Teaching, Research, and Learning). [Funding has been approved for one year, with the possibility of an additional two years of funding.] The PER community has hopes that this outlet may grow, in the long term, into a significant alternative publication venue for research papers in the field. However, the overall project has a wide scope and will require substantial time to ramp up from its start-up phases into full functioning. The journal component will require assembling additional editorial and production resources, a process that necessarily requires time and some initial testing. A significant challenge will be to develop, over time, a long-term funding mechanism that could sustain the new publication into the indefinite future, beyond the initial three-year period of NSF funding.

For now, the question of the reputation and ultimate acceptance of the new publication venue within the broader physics community is unresolved. This acceptance is critical to the journal's potential viability as an effective publication outlet for PER researchers. The current physics culture includes very few "electronic-only" journals; the vast majority of physics research papers are expected and required to have parallel paper publication. A new community still working to become generally accepted may incur a significant risk by concentrating a large fraction of its output in a venue seen as novel and somewhat "pioneering." The risk of depending primarily on a publication venue whose acceptance in the physics community is unproven may be particularly acute when considering the possible response of physics departments at major research universities. Their willingness to hire and promote PER faculty is critical to maintaining the credibility and influence of the field.

It is true that some purely electronic journals have become the primary publication routes in their field. Thus far, in the U.S. physics community, such publications have well-established and stable funding sources. Over time, the new electronic PER journal may evolve to a point where it can play a similar role. However, it is unrealistic to expect that any solely electronic journal can, in the short term, fulfill the role of primary publication outlet for all PER research articles. This is as much for "reputability" reasons as for logistical ones. A more practical approach might be for the new journal to take on a gradually increasing portion of the publication burden, as its production mechanisms and community acceptance grow and strengthen. Thus this would represent more of an "evolutionary," rather than a "revolutionary" approach. At best, it will be several years before the critical questions regarding the new venture can be answered positively and definitively. It will take some time before the new publication can be established as a legitimate counterpart to AJP within the PER and the broader physics communities

Meanwhile, the number of graduate students, post-doctoral researchers, and junior and senior faculty in PER continues its steady increase. The quantity of research being carried out is rapidly expanding, and adequate publication venues are an urgent, critical necessity to the continued viability of the field. The PER community has previously expressed its strong sentiment that the number of pages within AJP allocated to PER needs to expand at a rate commensurate with the rate of high-quality articles submitted. An increase in the amount of AAPT publication resources devoted to PER is more than adequately justified by the soaring levels of interest and participation in PER work by AAPT members that have been repeatedly demonstrated at the national and regional meetings of the AAPT. Moreover, any further delay in increasing PER publication within AJP will likely have devastating effects on the ability of workers in the field to maintain their effectiveness – if not their very existence – within their respective institutions.

As we have pointed out above, the recent trend has been that the number of PER papers within the main section of AJP has declined (in some years, to zero), while at the same time the number allowed in the PER Section has been rigidly constrained. The net result has been to greatly underserve the needs of the PER community within AAPT with regard to publication opportunities. A research community that has grown by more than an order of magnitude is being forced to operate with fewer publishing opportunities than existed 20 years ago.

***Conclusion:*** *For these reasons we call on the AAPT Executive Board and Publications Committee to take measures sufficient to allow rapid publication in AJP of PER papers accepted through the normal review process, including the following: (1) recommending very strongly to the editors of AJP that PER submissions be considered for inclusion in the main section of AJP on a par with submissions in other subject areas, and that they not be automatically directed to the PER section unless explicitly requested by the authors, (2) immediately increasing the total number of pages within AJP allocated to the PER Section, (3) allowing the option of including several shorter PER Sections within AJP more often than the current twice-per-year rate.*

## References


1. Jan Tobochnik, Editor and Edward F. Redish PERS Editor, "Physics Education Research Section (PERS)," Am. J. Phys. **70**, 666 (2002).
2. Edward F. Redish, "EDITORIAL," Am. J. Phys. **67**, S3 (1999).
3. A listing of PER papers published in AJP since 1972 is available as a separate document.
4. http://www.aps.org/statements/99_2.cfm
5. See Appendix B.
6. See Appendix C.

## Appendix A

A selection of PER papers published in AJP between 1976 and 1994:


F. Reif, Jill H. Larkin, and George C. Brackett, "Teaching general learning and problem-solving skills," Am. J. Phys. **44**, 212 (1976).

John W. Renner and William C. Paske, "Comparing two forms of instruction in college physics," Am. J. Phys. **45**, 851 (1977).

Richard Vawter, "Entropy state of a multiple choice examination and the evaluation of understanding," Am. J. Phys. **47**, 320 (1979).

David E. Trowbridge and Lillian C. McDermott, "Investigation of student understanding of the concept of velocity in one dimension," Am. J. Phys. **48**, 1020 (1980).

Audrey B. Champagne, Leopold E. Klopfer, and John H. Anderson, "Factors influencing the learning of classical mechanics," Am. J. Phys. **48**, 1074 (1980).

John Clement, "Students' preconceptions in introductory mechanics," Am. J. Phys. **50**, 66 (1982).

P. C. Peters, "Even honors students have conceptual difficulties with physics," Am. J. Phys. **50**, 501 (1982).

Robert J. Whitaker, "Aristotle is not dead: Student understanding of trajectory motion," Am. J. Phys. **51**, 352 (1983).

R. Cohen, B. Eylon, and U. Ganiel, "Potential difference and current in simple electric circuits: A study of students' concepts," Am. J. Phys. **51**, 407 (1983).

L. Viennot, "Analyzing students' reasoning: Tendencies in interpretation," Am. J. Phys. **53**, 432 (1985).

Peter W. Hewson, "Diagnosis and remediation of an alternative conception of velocity using a microcomputer program," Am. J. Phys. **53**, 684 (1985).

W. T. Griffith, "Factors affecting performance in introductory physics courses," Am. J. Phys. **53**, 839 (1985).

Ibrahim Abou Halloun and David Hestenes, "The initial knowledge state of college physics students," Am. J. Phys. **53**, 1043 (1985).

Ibrahim Abou Halloun and David Hestenes, "Common sense concepts about motion," Am. J. Phys. **53**, 1056 (1985).

Fred M. Goldberg and Lillian C. McDermott, "An investigation of student understanding of the real image formed by a converging lens or concave mirror," Am. J. Phys. **55**, 108 (1987).

Monica G. M. Ferguson-Hessler and Ton de Jong, "On the quality of knowledge in the field of electricity and magnetism," Am. J. Phys. **55**, 492 (1987).

Lillian C. McDermott, Mark L. Rosenquist, and Emily H. van Zee, "Student difficulties in connecting graphs and physics: Examples from kinematics," Am. J. Phys. **55**, 503 (1987).

Richard F. Gunstone, "Student understanding in mechanics: A large population survey," Am. J. Phys. **55**, 691 (1987).

Ronald K. Thornton and David R. Sokoloff, "Learning motion concepts using real-time microcomputer-based laboratory tools," Am. J. Phys. **58**, 858 (1990).

Alan Van Heuvelen , "Overview, Case Study Physics," Am. J. Phys. **59**, 898 (1991).

Patricia Heller, Ronald Keith, and Scott Anderson, "Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving," Am. J. Phys. **60**, 627 (1992).

Peter S. Shaffer and Lillian C. McDermott, "Research as a guide for curriculum development: An example from introductory electricity. Part II: Design of instructional strategies," Am. J. Phys. **60**, 1003 (1992).

S. Törnkvist, K.-A. Pettersson, and G. Tranströmer, "Confusion by representation: On student's comprehension of the electric field concept," Am. J. Phys. **61**, 335 (1993).

Beth Thacker, Eunsook Kim, Kelvin Trefz, and Suzanne M. Lea, "Comparing problem solving performance of physics students in inquiry-based and traditional introductory physics courses," Am. J. Phys. **62**, 627 (1994).

Robert J. Beichner, "Testing student interpretation of kinematics graphs," Am. J. Phys. **62**, 750 (1994).

Edward F. Redish, "Implications of cognitive studies for teaching physics," Am. J. Phys. **62**, 796 (1994).

S. Rainson, G. Tranströmer, and L. Viennot, "Students' understanding of superposition of electric fields," Am. J. Phys. **62**, 1026 (1994).

## Appendix B

The following departments have filled tenure-track PER positions within the past six and a half years; numbers in parentheses indicate number of positions filled. (In some cases the positions are joint between the physics department and another department.) Only five of these positions were filled with faculty who were hired with tenure:

1. American University (DC)
2. University of Arizona (2) [Physics Department; Astronomy Department]
3. Arizona State University
4. Buffalo State College (SUNY)
5. California State University, Chico
6. California State University, Fullerton
7. California State University, San Marcos (2)
8. University of Central Florida
9. Chicago State University
10. City College of New York (2)
11. University of Colorado (2) [Physics Department; School of Education]
12. Concordia College (MN)
13. Davidson College (NC)
14. Dickinson College (PA) (2)
15. Drury University (MO)
16. Grand Valley State University (MI)
17. Hawai'i Pacific University
18. High Point University (NC)
19. Iowa State University
20. Kansas State University
21. University of Maine (2)
22. University of Maryland
23. McDaniel College (MD)
24. University of Minnesota [General College]
25. New Mexico State University
26. North Carolina State University (2)
27. University of Northern Iowa (2)
28. The Ohio State University
29. Rochester Institute of Technology (NY)
30. Rutgers University (NJ) (2) [Physics and Astronomy Department; Graduate School of Education]
31. Seattle Pacific University
32. Southeastern Louisiana University
33. Southern Connecticut State University
34. Southern Illinois University, Edwardsville (3)
35. Southwest Missouri State University
36. University of Texas at Dallas [Department of Science/Mathematics Education]
37. University of Texas at El Paso
38. Texas Tech University
39. Towson University (MD) (2)

40. U.S. Air Force Academy (CO) (2)
41. University of Washington
42. Western Carolina University (NC)
43. Western Kentucky University
44. Western Michigan University
45. University of Wisconsin-Oshkosh
46. University of Wisconsin-Stout
47. Worcester Polytechnic Institute (MA)

## Appendix C

The following Ph.D.-granting physics (or physics and astronomy) departments have tenured, tenure-track, or research or teaching faculty members with a substantial or a primary interest in physics education research (* indicates non-tenure-track):

1. University of Arizona
2. University of Arkansas
3. Arizona State University
4. University of California, Davis*
5. University of Central Florida
6. City College of New York
7. University of Colorado
8. Harvard University
9. University of Illinois
10. Iowa State University
11. Kansas State University
12. University of Maine
13. University of Maryland
14. University of Massachusetts, Amherst
15. University of Minnesota
16. Mississippi State University
17. Montana State University
18. University of Nebraska
19. New Mexico State University
20. North Carolina State University
21. The Ohio State University
22. University of Oregon
23. Oregon State University
24. University of Pittsburgh*
25. Rutgers University
26. San Diego State University (joint program with University of California at San Diego)
27. Texas Tech University
28. Tufts University
29. University of Virginia
30. University of Washington
31. Western Michigan University
32. Worcester Polytechnic Institute