Chapter 4

Scholarship

4.1 Overview

During my five years at Berry have remained committed to producing scholarly work of the highest quality. Initially my work consisted of a continuation of the line of research that I began as a graduate student, namely the investigation of time-periodic quantum systems. Over the last five years, though, my scholarship has gradually taken on a pedagogical leaning. For example, I have had success involving students in my technical research and I am committed to involving even more students in my future work. Additionally, I have become more concerned with relating my scholarship to teaching. This attempt has incorporated two parallel tracks. Along one track I have attempted to find innovative ways of teaching material that I consider to be important, but which is frequently not included in undergraduate curricula. This work has direct application in the undergraduate classroom and stems from my own teaching at Berry. Along the other track I have attempted to make current research in my field accessible to those with a background in undergraduate physics. The work I have done in this second track is not directly applicable to undergraduate physics courses, but it does serve to increase the accessibility of the material to undergraduates who are interested in learning about cutting-edge research. I hope to continue my work along both of these tracks in the future.

The strong desire to connect my scholarly work with pedagogy has not prevented me from publishing. Indeed, I have published technical articles with student co-authors in the most prestigious physics journals in the world. I have also published pedagogical articles in the premier journal for physics pedagogy at the undergraduate level. I am the first author, with primary responsibility for conducting the research and writing the paper, on all but one of the articles I have published during my time at Berry and all but one of the articles I published prior to my time at Berry. Copies of all of my publications are available in Appendix E. In addition I have presented at regional, national, and international conferences. The students with whom I have worked have all presented their results at the Berry Student Research Symposium, and one has also presented his research at a national meeting. Table 4.1 summarizes these activities.

Academic Year	**Published Papers**	**Presentations**	**Student Presentations**	**Total**
2001-2002[†]	1	2	0	3
2002-2003	1	1	2	4
2003-2004	0	4	0	4
2004-2005	1	0	2	3
2005-2006	2	2	3	7

[†] The data for the 2001-2002 academic year represents work completed in July and August of 2001, prior to the start of my term at Berry.

Table 4.1: Summary of scholarship activities

The quality of my work, and that of my student co-authors, is indicated by the quality of the journals in which I have published and the conferences at which I have presented. Table 4.2 shows acceptance rates,

impact factors, and weighted PageRank (a method of measuring the prestige of the journal, as opposed to its popularity) for the journals in which I have published during my career. Note that during my time at Berry (as opposed to my time at the University of Texas) I have published in all but one (*Physical Review A*) of these journals. It should also be noted that these are all *international* journals, which receive a large number of submissions from outside the United States.

Journal Title	**Acceptance Rate**[a]	**Impact Factor (Rank)**[b]	**PageRank (Rank)**[c]
American Journal of Physics	≈25-30%	0.792	NA
Physical Review A	60%	2.589	1.55×10^{-3} (8)
Physical Review E	62%	2.202	2.34×10^{-3} (5)
Physical Review Letters	37%	7.035 (7)	8.41×10^{-3} (1)

[a] Acceptance rates for regular articles during 2004.
[b] From the 2003 Journal Citation Report published by Thomson ISI. Rank is among all physics journals in the report.
[c] Weighted PageRank is a measure intended to reflect the prestige of the journal (see "Journal Status," by Johan Bollen, Marko A. Rodriguez, and Herbert Van de Sompel, `arxiv.org/cs.DL/0601030` in Appendix H). Rank is among all physics journals in the 2003 Journal Citation Report.

Table 4.2: Indicators of journal quality

Unfortunately, the work I have done at Berry has been in print for only a short time and therefore it is difficult to judge the impact of my work my measuring the number of citations it has received. However, the work I published as a graduate student at the University of Texas has been out for a long enough time that its impact can be directly measured. Table 4.3 shows the numbers of citations for each of the articles I published prior to my time at Berry. The table shows the total number of citations for each paper, the number of citations from papers not co-authored by me, and the number of citations from papers not co-authored by me or any of my co-authors. As an additional indication of the importance of my work I have included referee reports on several of my papers (including all of the papers I have published while at Berry) in Appendix F. I hope this information serves to indicate the level of respect with which my work is regarded by my peers.

Title of Article	**Total Citations**	**Excl. Self**	**Excl. Co-authors**
High harmonic generation in systems ...	9	7	5
Changes in Floquet-state structure ...	17	15	9
Phase-space picture of resonance ...	5	4	2

Table 4.3: Citations of prior work

4.2 Publications

The following publications include only refereed articles that I have completed during my time at Berry College. Publications with Berry student co-authors are marked with an asterisk (*). For a complete list of my publications, including non-refereed abstracts, see my CV.

- Ron Taylor and Todd Timberlake, "Tearing Plastic: A laboratory exercise on fractals and hyperbolic geometry," to be published in *PRIMUS*.
- T. Timberlake, "Random numbers and random matrices: quantum chaos meets number theory," *American Journal of Physics* (2006) **74**, 547-553.
- T. Timberlake, F. Petruzielo, and L. E. Reichl, "Localization of Floquet states along a continuous line of periodic orbits," *Physical Review E* (2005) **72**: 016208. *

- T. Timberlake, "A computational approach to teaching conservative chaos," *American Journal of Physics* (2004) **72**: 1002-1007.
- T. Timberlake and J. V. Foreman, "Correlation of the photodetachment rate of a scarred resonance state with the classical Lyapunov exponent," *Physical Review Letters* (2003) **90**: 103001. *

4.3 Presentations

The following is a list of professional presentations I have given since being hired by Berry College. Presentations that had Berry student co-authors are marked with an asterisk (*). My travel to give the presentation marked with a dagger (†) was partially funded by a $1500 grant from the National Science Foundation (see invoice in Appendix H).

- T. Timberlake, "Inquiry-based physics for non-science students," *Ninth Annual Legacy of R. L. Moore Conference*, Austin, TX, May 2006.
- Ron Taylor and Todd Timberlake, "How big is the Cantor set?," invited talk at Lee University, Cleveland, TN, March 2006.
- T. Timberlake, "Writing-intensive quantum mechanics," *2006 Winter Meeting of the American Association of Physics Teachers*, Anchorage, AK, January 2006.
- T. Timberlake, "A computational approach to teaching conservative chaos," *Gordon Research Conference on Physics Research and Education*, Mount Holyoke College, MA, June 2004.
- T. Timberlake, "Teaching chaos theory to undergraduate physics majors," *Annual Meeting of the Georgia Academy of Science*, Mount Berry, GA, March 2004.
- T. Timberlake, "Quantum-classical correspondence in driven open quantum systems," invited talk at Vanderbilt University, Nashville, TN, January 2004.
- T. Timberlake and J. V. Foreman, "Correlation of photodetachment rate and Lyapunov exponent for a scarred resonance state," *International Conference on Dynamical Chaos in Classical and Quantum Physics*, Novosibirsk, Russia, August 2003. *†
- T. Timberlake and J. V. Foreman, "Correlation of photodetachment rate and Lyapunov exponent for a scarred resonance state," *Meeting of the Southeastern Section of the American Physical Society*, Auburn, AL, November 2002. *
- T. Timberlake and L. E. Reichl, "Resonance creation and periodic orbits," *International Conference on Quantum Chaos*, Cocoyoc, Mexico, July 2001.
- T. Timberlake and L. E. Reichl, "Delocalization and superscars in the driven square well," *International Conference on Quantum Chaos*, Cocoyoc, Mexico, July 2001.

4.4 Research with Students

The research I have conducted with Berry students is described below.

4.4.1 John Foreman

During the summer of 2002 I worked with John Foreman, who had just graduated from Berry in May 2002, on a project that involved calculating eigenvalues and eigenstates for the periodically-driven inverted Gaussian potential well. John helped me to create a parallel computing cluster to carry out this work, and he also adapted several programs that I had written previously so that these programs could run on the new computing cluster. We obtained an important result from this work and published our finding in *Physical Review Letters*, the most prestigious physics journal in the world. This work also was presented

regionally (at a meeting of the Southeastern Section of the American Physical Society in Auburn, AL) and internationally (at a Dynamical Chaos Conference in Novosibirsk, Russia). I obtained a $1500 travel grant from the National Science Foundation to present this work in Novosibirsk (see copy of invoice in Appendix F). Finally, my work with John was featured in a Berry Magazine article (available in Appendix F).

4.4.2 Wes Taylor, Matt Lewis, and Justin Leonard

During the spring of 2003 I worked with these three students on a small project that was an extension of a project they had completed for my PHY 402 class the previous fall. Although their results were not suitable for publication, they did present their findings at the 2003 Berry Student Research Symposium.

4.4.3 Frank Petruzielo

During the summer of 2004 I worked with Frank Petruzielo on a project investigating the effect of a continuous line of classical periodic orbits on the eigenstates of a quantum system. Frank generated data using several programs that I had written, as well as one he wrote himself, and carefully analyzed the data in a variety of ways. Our results were published in *Physical Review E* and Frank presented this work at the Berry Student Research Symposium. In addition, our work was featured in President Colley's essay on student research in Berry Magazine (available in Appendix F).

4.4.4 Courtney Griffin and Frank Petruzielo

During the 2004-2005 academic year I worked with Courtney Griffin and Frank Petrizielo on a project investigating eigenvalue statistics of weakly-driven systems. These students used programs and routines that I had created to conduct statistical analyses of a variety of eigenvalue sequences. Courtney presented their results at the 2005 Berry Student Research Symposium, and Frank presented their work at a national meeting (the 2006 AAPT Winter Meeting in Anchorage, AK) as well as the 2006 Berry Student Research Symposium. In addition, Frank and Courtney co-authored a paper submitted to the *Journal of Undergraduate Research in Physics*. This paper is still under review.

4.4.5 Sarah Earl

During the spring of 2006 Sarah Earl conducted a small-scale research project with me as part of her "honorization" of PHY 402I. She studied Berry's Foucault pendulum experimentally and using numerical models. She presented her results at the 2006 Berry Student Research Symposium.

4.4.6 Future Work

During the fall of 2006 I will have four students conducting research under my supervision. Seniors Jeff Tucker and Ryan Bessey will likely work on a project involving statistical measures of randomness in prime numbers and pseudo-primes (i.e. Hawkins primes and Cramer primes). Sophomores Trey Bobo and Robby Boston will begin a long-term project studying the effects of asymmetry on wavepacket revivals in the infinite square well. This work is part of a collaboration that involves Dr. Amal Das of Dalhousie University in Nova Scotia and Dr. Mario Belloni of Davidson College in North Carolina. I also have ideas for a few other projects that would be appropriate for undergraduates.

4.5 Scholarship of Teaching

Some of my scholarship activities have been devoted to developing instructional methods for a variety of topics.

4.5.1 Teaching Chaos Theory to Undergraduates

For my PHY 302 and 402I courses I have developed a method for teaching chaos theory at the undergraduate level using *Mathematica* software. I have published some of this work in the *American Journal of Physics*, the leading pedagogical physics journal at the advanced undergraduate level. In addition, I have presented this work at the 2004 Meeting of the Georgia Academy of Science and at the 2004 Gordon Research Conference on Physics Research and Education.

4.5.2 Writing-Intensive Quantum Mechanics

I have developed a set of writing assignments for PHY 430I which I believe are very successful in encouraging students to think deeply about the conceptual foundations of quantum mechanics. I have presented these assignments, along with my instructional strategy for the course, at the 2006 Winter meeting of the American Association of Physics Teachers in Anchorage, AK.

4.5.3 A Laboratory Activity for Liberal-Arts Mathematics

In the fall of 2004 I taught a section of PHY 101 that was paired with Dr. Ron Taylor's MAT 105 course. As part of this experience Ron and I developed a laboratory activity which the students completed as part of their coursework for PHY 101, but which integrated several key concepts from the MAT 105 course. Ron and I wrote an article describing this lab activity and the article will be published in *PRIMUS*, a mathematics pedagogy journal.

4.5.4 Future Work

I plan to adapt a handout on Dirac notation that I created for my Quantum Mechanics course into an article for *American Journal of Physics*. I also plan to write an article at some point on the activities that I have developed for the PHY 101 course. I will likely give several talks on pedagogical matters at future AAPT meetings. Ultimately I would also like to write an article for *American Journal of Physics* suggesting ways that topics in the philosophy of science could be incorporated into physics courses at the undergraduate level.

4.6 My Lifelong Learning

My scholarship activities have greatly contributed to my own lifelong learning by allowing me to explore areas of physics that are related to, but not actually part of, my own field of research. This is particularly true in regards to the two papers I have published in the *American Journal of Physics*. My own research is in the area of quantum chaos. The first paper I published in *AJP* describes a method for teaching students about classical chaos. This material is certainly related to my work, but I really had to learn it myself before I could figure out how to teach it! Now, my field of quantum chaos is actually composed of two main branches: properties of wavefunctions, and properties of eigenvalues. My research has been exclusively in properties of wavefunctions. My second paper in *AJP*, however, is an exposition of eigenvalue statistics in quantum chaos. Again, I had to learn a great deal before I could attempt to write this paper. I have found that these activities have greatly enriched my understanding of my own field, while simultaneously expanding my knowledge into new areas.

My research activities at Berry have also forced me to learn new computational skills. During my time at the University of Texas I wrote all of my computational physics programs in Fortran and ran these programs serially on high-performance computers (mostly on a Cray J-90). To conduct my work at Berry I have had to adapt these programs to run on a cluster composed of several desktop computers. I have created two clusters, one consisting of my own Powermac G4 research machines (see Bifrost Cluster web page at `fsweb.berry.edu/academic/mans/ttimberlake/bifrost/` or printout in Appendix F) and another consisting of the Wintel machines in the Physics labs and the Science Computer lab. The Bifrost Cluster is featured on the Dauger Research Pooch Users Page (`www.daugerresearch.com/pooch/users.shtml`). In addition, Berry student John Foreman and I have re-written much of my code using the Message Passing

Interface to allow the programs to run in parallel on multiple machines in the cluster. This experience has certainly enhanced my knowledge and ability as a scientific programmer.

I certainly expect to continue learning new things. Recently I have read extensively about the distribution of prime numbers, quantum wavepacket revivals, and the philosophy of physics (specifically determinism). While I plan to carry out scholarly work involving all three of these topics, I have enjoyed continuing my education regardless of whether or not it contributes directly to my professional success.