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December 15, 2008

Dear Connie,

Please accept our application for a Mellon 23 grant. I'll be happy to serve as the liaison for our proposal. If you have any questions, please don't hesitate to ask.

Sincerely yours,

Lynne A. Molter
Professor and Chair
Department of Engineering

and

K. Ann Renninger
Professor and Chair
Department of Educational Studies

Learning and Teaching Physical Sciences in the Liberal Arts College: Forging a Research Agenda

Despite their success in teaching, e.g. high rates of PhD production (27 of the top 40 institutions for the years 1995-2004 are small colleges), small colleges experience high attrition of students from the physical sciences: chemistry, computer science, engineering, mathematics, and physics. This problem is particularly acute among underrepresented minorities, women, and first-generation college students. Additionally, other fields in social sciences and humanities attract many more students who are undecided about what to study when they apply to college than the physical sciences do.

The Workshop leaders propose to join with 4 peer institutions with different institutional structures to identify research questions that could help to determine the reasons students migrate out of these fields, and how this situation might be addressed. Sample questions might include the following. What is the predictive value of SAT Math scores for retention? What enables students with weak backgrounds to succeed? When are study groups effective?

As part of an invited submission to the Sloan Foundation, Workshop leader Molter has been working with a consortium of 10 institutions to develop a research collaboratory, a resource for multiple institutions to pool data on topics specific to attrition and to conduct research for partner institutions^[1]. One challenge of such a collaboratory is that there are not a lot of data describing the strong students attracted to small college contexts like the Mellon 23, and the research that has been reported has come from large institutions. In fact, the expectation in the field is that large institutions might emulate the practices of the small college. The good and bad news is that the successes of some students in the physical sciences in the small colleges overshadow the difficulties of others. Representation of the needs of students in small colleges is essential for the collaboratory; more importantly perhaps, participation in this type of group would provide common analysis tools and research capacity to small college participants. It is, however, also essential that the nature of the tools and the focus of the research undertaken be informed by the needs of the small college.

In the proposed Workshop, two faculty members in the physical sciences at each of 6 institutions (along with Swarthmore faculty members Lynne Molter and Ann Renninger) will attend an initial meeting at Swarthmore College and will continue to collaborate through monthly video-conferences over 15-18 months. They will identify and work together to address a small number of immediate questions for their institutions. Resources from the Workshop leaders' prior work to design survey and interview protocols will be made available to Workshop participants. Swarthmore College will also provide research support for analysis of any pooled efforts to study attrition in the physical sciences.

In addition to providing participants with opportunities to network and share perceptions, the proposed Workshop will also provide opportunities to collect and pool data on questions of immediate interest to them and their institutions, and to inform themselves and the proposed collaboratory about the research questions and forms of intervention possible in the small college.

^[1] Footnote:

The proposed Workshop will be informed by prior work by the Workshop leaders and will be used to inform the next generation of research on these issues. A body of prior research results, a data template, and a survey instrument (see below) will be provided prior to the proposed Workshop based on previous studies undertaken by its leaders. Demographic data, grades in gateway courses, SAT scores, and other institutional data will be examined using descriptive methods, regressions, and decision tree analyses. One important outcome will be a description of the group(s) of students most at risk of out-migrating in each discipline at each institution. The survey includes questions about demographics; career plans; past experiences; motivation; interest; attitudes; influences of others, one's own perception of ability, college courses, professors, etc. on students' decisions to major; these complement the institutional data.

The Sloan Foundation supported the development of the data template and survey instrument in an exploratory grant involving 11 highly selective colleges and universities; it has invited a second proposal for a full grant to collect an enhanced data set, launch a second generation survey, and link these results. Participants in this Mellon 23 workshop would also have priority for invitation to join the second Sloan-supported effort. The liberal arts college members would be positioned to take a leadership role in defining the research directions of the larger group, which is expected to become self-sustaining over time, to address the changing landscape of student access and retention in NSE fields, and to develop effective interventions to enable students to thrive in NSE fields. Outcomes of this type of research will enable the collection of data and design of interventions that can make a difference in the small college context, addressing deficiencies in background, as well as social issues.

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a. Professional Preparation

B.S., Engineering, and B.A., Mathematics, 1979, Swarthmore College, Swarthmore, PA.

S.M., Electrical Engineering and Computer Science, 1983, Massachusetts Institute of Technology, Cambridge, MA, "Integrated Optical Picosecond Signal Processing Devices."

Sc.D., Electrical Engineering and Computer Science, 1987, Massachusetts Institute of Technology, Cambridge, MA, "Integrated Optical Multiple Waveguide Coupler Switches and Lenses."

b. Appointments

1987-present: Professor, Associate Professor and Assistant Professor, Department of Engineering at Swarthmore College.

Research interests (assisted by students) include Photonics, Photonic Crystal Devices, Optoelectronics, Solid State Physics, Guided Wave Phenomena, Integrated Optics, Quantum Electronics, Electromagnetics; Student Learning in Science, Technology, Engineering, and Mathematics (STEM) Fields, Retention of Students in STEM fields.

Teach courses including communication systems, electromagnetic field theory, electric circuits, linear systems, physical electronics, and electronics.

c. Publications (* indicates student co-author)

E. A. Cheever, L. A. Molter, and B. A. Maxwell, "A Remote Wireless Sensing and Control Laboratory," presented at American Society of Engineering Education Annual Conference, Nashville, TN, June 2003.

J. G. Makin* and L. A. Molter, "Generalized Switching, Splitting, and Multiplexing Operations Using Circular Arrays of Coupled Waveguides," presented at Optical Fiber Communication (OFC) Conference and Exposition, Session MF, Atlanta, GA, March 24, 2003.

J. Hudgings,* L. A. Molter, and M. Dutta, "Design and Modeling of Passive Optical Switches and Power Dividers Using Non-Planar Coupled Fiber Arrays," IEEE J. Quantum Electronics, QE-36(12), 1438-1444, December 2000.

E. R. Thoen,* L. A. Molter, and J. P. Donnelly, "Exact Modal Analysis and Optimization of NxNx1 Cascaded Waveguide Structures with Multimode Guiding Sections," IEEE J. Quantum Electronics, QE-33(8), 1299-1307, August 1997.

C. G. R. Geddes* and L. A. Molter, "Nonlinear Optical Slab Waveguide Devices in AlGaAs/GaAs," presented at the Conference on Lasers and Electrooptics, Paper CTuI23, Baltimore, MD, May 22-26, 1995.

E. R. Thoen,* L. A. Molter, and J. P. Donnelly, "Analysis of Multiple Input NxM Waveguide Couplers with Multimode Guiding Sections," presented at the Conference on Lasers and Electrooptics, Paper CThI 21, Baltimore, MD, May 22-26, 1995.

E. R. Theon,* L. A. Molter, and J. P. Donnelly, "Analysis of N x M Waveguide Splitters and Couplers with Multimode Guiding Section," presented at the International Symposium on Guided-Wave Optoelectronics: Device Characterization, Analysis, and Design, Polytechnic University, New York, NY, October 1994.

D. J. Jones* and L. A. Molter, "A Generalized Method for Coupled Mode Analysis of Fiber Optic Arrays," IEEE J. Quant. Electronics, QE-30(1), 119-125, January 1994.

d. Synergistic Activities

Why Students Leave STEM Fields: Development of a Common Survey Tool.

PIs: Robert Koff and Larry Handlin, Washington University in St. Louis, and Lynne Molter and K. Ann Renninger, Swarthmore College. Partially supported by the Johnson Foundation; under review at the Alfred P. Sloan Foundation.

Retaining Students in Natural Science and Engineering Majors: Understanding the Problem in the Small College.

Co-PIs: Lynne Molter and K. Ann Renninger. Supported by the Alfred P. Sloan Foundation (2007-2008) to characterize retention problems in STEM fields in the small liberal arts college.

The Role of Scientific Literacy in the Liberal Arts Curriculum.

PI: Lynne Molter. Supported by William and Flora Hewlett Foundation (2000-2004) to assess and improve the scientific background of all Swarthmore students.

Preliminary work regarding study strategies.

PIs: Erik Cheever, Lynne Molter, and K. Ann Renninger. Supported by the Mellon Foundation (2001) to perform literature searches and background studies related to this project.

Facilitator

- National Research Council (NRC) Board on Engineering Education, Planning Meeting on Implementation of Engineering Criteria 2000, Seattle, WA, June 1998.
- Integrating Math and Science Teaching (IMAST), faculty facilitator (1995-1998) for 25 local teachers to enable substantive changes in their curricula.

Workshop Participant

- ABET (Accreditation Board for Engineering and Technology)/ASEE National Conference on Outcomes Assessment for Engineering Education, Washington DC, September 19-20, 1997.
- NRC (National Research Council)/NSF Undergraduate Convocation: From Analysis to Action: Undergraduate Education in Science, Mathematics, Engineering, and Technology, Washington, DC, April 9-11, 1995.
- NSF Presidential Young Investigator Colloquium on America's Academic Future, Report Title NSF91150.

e. Collaborators & Other Affiliations

i. Collaborators:

Cheever, Erik: Swarthmore College
Geddes, Cameron: Lawrence Berkeley Laboratory
Herczfeld, Peter: Drexel University
Hudgings, Janice: Mount Holyoke College
Jemison, William: Lafayette College
Jones, David: University of British Columbia
Koff, Robert: University of Washington in St. Louis
Makin, Joseph: University of California, Berkeley
Maxwell, Bruce: Swarthmore College
Renninger, K. Ann: Swarthmore College
Thoen, Erik: Massachusetts Institute of Technology

ii. Graduate Advisor: Haus, Hermann A., Massachusetts Institute of Technology

iii. Thesis Examiner: Flood, Kevin, University of Pennsylvania

K. ANN RENNINGER, Ph. D.

a. Professional Preparation

- Educational Testing Service, Developmental Psychology, Post-doctoral Fellow, 1985-6
- Bryn Mawr College, Education and Child Development, Ph.D., 1983
- Bryn Mawr College, Education and Child Development, M.A., 1979
- University of Pennsylvania, B.A., 1973

b. Appointments

- 1980- present, Swarthmore College, Swarthmore, PA, Department of Educational Studies, Professor
- 1974-77, George School, Newtown, PA, teacher

c. Publications

i. Five publications related to the proposed project

- Hidi, S. & Renninger, K. A. (2006). *The four-phase model of interest development*. *Educational Psychologist*, 41 (2), 111-127.
- Renninger, K. A. (2007). *Interest and motivation in informal science learning*. White Paper prepared for the Committee on Learning Science in Informal Environments of the National Academy of Education.
- Renninger, K.A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone & J.M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance*. (pp.373-404). New York: Academic Press.
- Renninger, K. A. (in press). Learner interest and identity: An inductive model for instruction. *Educational Psychologist*.
- Renninger, K. A., Bachrach, J. E., & Posey, S. K. E. (2008). Learner interest and achievement motivation. In M. Maehr, S. Karabenink, & T. Urda (Eds.), *Social psychological perspective on motivation and achievement. Volume 15: Advances in Motivation and Achievement* (pp. 461-492). London: Emerald.

ii. Five significant publications

- Renninger, K.A. (1998). Developmental psychology and instruction: Issues from and for practice. In I.E. Sigel & K.A. Renninger (Vol. Eds.) *Child psychology in practice*, Volume 4. In W. Damon (Gen. Ed.), *Handbook of child psychology* (pp. 211-274), 5th edition. New York, NY: John Wiley and Sons.
- Renninger, K.A., Farra, L., & Feldman-Riordan, C. (2000). The impact of The Math Forum's Problems of the Week on students' mathematical thinking. *Proceedings of ICLS 2000*. Mahwah, NJ: Erlbaum. (www.mathforum.org/articles/rennin2_2000.html)
- Renninger, K. A., & Hidi, S. (2002). Student interest and achievement: Developmental issues raised by a case study. In A. Wigfield & J. S. Eccles (Eds.), *Development of Achievement Motivation* (pp. 173–195). New York: Academic Press.
- Renninger, K. A., Ray, L. S., Luft, I., & Newton, E. L. (2005). Coding online content-informed scaffolding of mathematical thinking. *New Ideas in Psychology*, 23, pp. 152-165.

Renninger, K. A., Sansone, C., & Smith, J. L., (2004). Love of learning. In C. Peterson & M. E. P. Seligman (Eds.) *Character strengths and virtues: A classification and handbook*. New York: Oxford University Press.

d. Synergistic Activities

- Consultant on Motivation and Interest, Committee on Learning Science in Informal Environments of the National Academy of Education, 2006-2007.
- Co-PI, Sloan Foundation project: Retaining students in Natural Science and Engineering Majors: Understanding the problem in the small college, 2007-2008.
- Co-PI, Sloan Foundation project: Why students leave STEM fields: Development of a common survey tool, 2007-2009.
- Co-PI, NSF Science of Learning Center Catalyst grant, *Engaged Learning in Online Communities*, 2005-2007.
- Evaluation, Flora and William Hewlett Foundation Grant to Swarthmore College, *The Role of Scientific Literacy in the Liberal Arts Curriculum*, 2001-2005.
- Evaluation, NSF Project: *Online Mentoring Grant* to The Math Forum at Drexel University, 2002-2004.
- Evaluation, NSF Project: *Training and Resources for Assembling Interactive Learning Systems (TRAILS)*, a collaboration of The Math Forum and SRI International, 2002-2005.
- Research and Evaluation, The Math Forum, 1992- present.
- Advisory Panel, NASA Explorer Schools Project, 2004-2006.
- Advisory Board, Syracuse University Science of Learning Center, *Engaging Learning in the 21st Century*, 2004-2006.
- Participant, NSF Supported *Workshop on Cyber Learning* (Ed Lazowska and Roy Pea, Chairs), January 2005.
- Participant, Organizer, and Writer, NSF-sponsored *Participant Interaction in Digital Library Workshop*, Drexel University, February, 2004.
- Participant and contributor, NSF *NSDL Evaluation Workshop*, October , 2003.
- CILT Mini-Grant Recipient, with Shumar, Hoadley, Recker, & Schlager, May 2003.
- CILT Community Tools Workshop Coordinating Committee, 2002.
- Participant, *STEM-Lab Workshop* on supporting shared tools for NSDL research, February 2002
- Task Force on Web Methodology, *Association of Internet Researchers*, 2000-2003.
- Co-Editor, *Child Psychology and Practice*, Vol. 4, *Handbook of Child Psychology* (Richard Lerner and William Damon, Gen Eds.), 1998, 2006.
- Editorial Boards, *Applied Developmental Psychology; Cognition and Instruction, Motivation and Emotion*
- Project and Grant Reviewer, Italian Ministry for Universities and Research, National Academy of Education, MIUR- COFIN, National Science Foundation, Spencer Foundation, SSHRC/CRSH.

Evaluation

Participants in the workshop will fill out an evaluation form including both qualitative as well as quantitative data. Open ended questions will be included. The results of this evaluation will be tabulated where possible, and qualitative information will be summarized.

Faculty will be asked to evaluate any interventions they develop as a result of this work, both from the faculty members' perspectives, as well as students' perspectives. Quantitative comparisons between results before and after the intervention will be requested where possible.

Budget

	Cost per Person	Workshop Leaders Swarthmore (2)	Workshop Leaders Carlton (2) and Smith (2)	Workshop Participants 8	TOTAL
Travel	600	0	2400	4800	7200
Lodging	150	0	600	1200	1800
Subsistence	200	400	800	1600	2800
Administrative Expenses					200
TOTAL REQUESTED					12000

College Contributions: in kind assistance from Director of Institutional Research and the Engineering Department's Administrative Assistant.