

Directorate for Social, Behavioral & Economic Sciences
Office of the Assistant Director
4201 Wilson Boulevard, Suite 905
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MEMORANDUM

DATE: June 12, 2009

TO: Dr. James Lightbourne, Senior Advisor for the Integration of Research & Education

FROM: David W. Lightfoot, AD, SBE

SUBJECT: Report of the Committee of Visitors for the Science of Learning Centers (SLC) Program, a cross-Foundation activity managed within the SBE directorate

The COV report was discussed and accepted at the May 21-22, 2009 meeting of the Social, Behavioral, and Economic Sciences Advisory Committee. Attached, please find SBE's formal response to the recommendations of the COV, the COV report, lists of COV members, COV Charge and SBE Advisory Committee members.

The COV consisted of 9 members, including the chair (a member of the SBE AC), selected for their background and expertise reflecting the multidisciplinary nature of the SLC program, as well as for management and evaluation experiences relevant to large-scale research centers. It was composed of 3 women and 6 men, including 2 members of underrepresented minorities. One COV member is a co-PI on a workshop award; no other member has received funding from the SLC program. More than half of the members had no experience (as reviewer or applicant) with the SLC program. Proposals for review by COV were randomly selected, and conflicts of interest were dealt with by blocking the member's access to proposals for which they had a conflict of interest.

Attachments

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CHARGE TO THE COMMITTEE OF VISITORS

Directorate for Social, Behavioral and Economic Sciences Science of Learning Centers (SLC) National Science Foundation

March 9-11, 2009

Guidance to the COV: This Science of Learning Center (SLC) COV activity will be different from the standard NSF process because of the nature of the SLC program. The SLC program is an NSF-wide program funded through the Office of Integrative Activities (OIA) and managed by the Directorate for Social, Behavioral and Economic Sciences (SBE).

The SLC program consists of six active SLCs, three for which awards were made in FY 2004 (Cohort 1) and three for which awards were made in FY 2006 (Cohort 2). Catalyst awards made in FY 2004 are no longer part of the active portfolio. In addition, the SLC program has made a number of awards for supplements, Small Grants for Exploratory Research (SGERs), and workshops; almost all of this activity has been accomplished with internal review by relevant NSF staff.

NSF will provide the COV with all materials related to currently active awards and proposals on which the program took action during the period October 1, 2005 – September 30, 2008. In addition, the SLC staff will determine with the COV chair how actions taken prior to October 1, 2005 will be explored during the COV review. The decision materials on all program actions will be available to COV members without conflicts of interests on request, with concurrence of the COV chair.

The COV report should provide a balanced assessment of NSF's performance in two primary areas: (A) the integrity and efficiency of the **processes** related to proposal review and award management and oversight; and (B) the quality of the **results** of NSF's investments that appear over time. The COV also explores the relationships between award decisions and program/NSF-wide goals in order to determine the likelihood that the portfolio will lead to the desired results in the future. Discussions leading to answers for Part A of the Core Questions will require study of confidential material such as declined proposals and reviewer comments. *COV reports should not contain confidential material or specific information about declined proposals.* Discussions leading to answers for Part B of the Core Questions will involve study of non-confidential material such as results of NSF-funded projects.

When looking at operations, the typical COV focuses primarily on addressing questions about the quality of the merit review process for proposals, including the appropriateness of external reviewers and panelists and use of the NSF review criteria. This COV will spend more of its time addressing program operations in the context of award oversight and management. There are regular interactions between NSF staff and each of the centers, as well as an annual site visit for each center involving external experts. You will be asked about the appropriateness of the site visit teams, the extent to which NSF and special SLC merit review criteria are addressed in the site visits, and the extent to

which the site visit reports provide guidance to the program on the quality of the center activities and the effectiveness of program operations. NSF staff will also describe the rather unusual management structure for the SLCs and ask about its appropriateness and effectiveness for the program.

Results and outcomes from the SLC program are the subject of the next set of questions. You will be provided with examples from each of the SLCs, as well as information on activities of the program as a whole.

Finally, SBE has developed some questions specific to the SLC program for your consideration as we move toward the next stages of program activity. These questions, which are included in the COV template, are also reproduced below.

Please note that you may choose to decline to respond to questions on this template if you decide that they are inappropriate or not applicable to your review. The reports generated by COVs are used for many purposes, from informing the program staff and NSF management about important directions for the program's future to assessing agency progress in order to meet government-wide performance reporting requirements. In this latter use, they are made available to the public. Since material from COV reports is used in NSF performance reports, the COV report may be subject to an audit.

We encourage COV members to provide comments to NSF on how to improve in all areas, as well as suggestions for the COV process, format, and questions. For past COV reports, please see <http://www.nsf.gov/od/oia/activities/cov/covs.jsp>.

COV template questions specific to the SLC program:

1. Based on the presentations, your reading of the Center documentation, and the information about supplements, workshops, etc., what evidence do you see of the Centers leveraging their relationships with the SLC Program, with one another and with the nascent network of Centers? To what extent is this adding value to their ability to meet their own Center-based goals and results?
2. Is there evidence of new research paradigms, organizational structures, or intellectual structures are emerging from the work of the Program or the Centers? If so, are there any observations you can make about the impacts on the culture of research and research transfer for learning and education?
3. What observations do you have regarding the role of external evaluation in improving Center performance?
4. NSF is currently planning an external evaluation of the SLC program. What guidance can you provide on the most appropriate areas of focus for the external evaluation? What types of data might best enable such a focus?

5. Please provide any comments you may have on the SLC management model, including the roles of the SLC program officers, the SLC Coordinating Committee, and the technical coordinators.

6. What recommendations can you make to improve the program, particularly with respect to leveraging NSF's own learning about research and education as a result of the program?



National Science Foundation
Science of Learning Centers Program's
Committee of Visitors' (COV) Meeting
March 9-11, 2009

SLC: Committee of Visitors' Members

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Cover Letter for the Report of the COV for the NSF Science of Learning Centers Program, March 9-11, 2009

It is the request of the Committee of Visitors convened for the Science of Learning Centers Program that this cover letter be made part of the COV Report, and that it travel with the report as a cover letter.

The standard form does not precisely fit the needs of this COV in making its examination or in reporting the results. Therefore, the standard COV template was modified with a set of additional questions in Part C, Other Topics. We provide this cover letter to explain how the COV approached this assignment and to provide context for interpreting comments made in the report form.

The Science of Learning Centers Program is a major success. It exemplifies NSF's special responsibility for making high-risk/high-return investments on behalf of the nation. The topic of the SLC Program is of the highest importance and the magnitude of the challenge it poses is great.

The COV was impressed with the uniqueness of the SLC Program, its vital role in advancing intellectual merit and broader impacts of science and engineering research and education, and its potential as a transformative endeavor. The purpose of NSF is learning: NSF embodies discovery and transmission of knowledge. It is essential that NSF support research into the nature of learning itself.

A number of NSF programs study learning; the SLC Program embraces learning in three ways:

- *As a program of cross-disciplinary study to advance learning of all kinds.* The breadth of study embraced by the SLC Program is extraordinary, from brain science to computer science and from research methods to classroom teaching. The centers attempt to go beyond mere complementary interaction to genuine inter-disciplinary action.
- *As an emergent learning network, going beyond a set of stand-alone centers of excellence.* The idea of the centers as nodes in a learning network is novel and holds great promise, especially as younger participants raised in the era of Internet and cellular telephone communications explore ways to act as a large community of practice rather than simply as members of local projects. The network is growing by exploiting clever mechanisms such as Catalysts, SGERs and Supplements. This network is also rapidly growing at the international level. Much of this network expansion is enabled by cyber-infrastructure, making the SLC Program an important test-bed in the use of CI for community-building.
- *As a sophisticated "learning-by-doing" project in its own right, building knowledge within NSF that should be valuable for future innovative programs of this kind.* The COV uses the term "learning-by-doing" as it is used in economics (cf. Arrow 1962; Sheshinski, 1967): to refer to the accumulation of knowledge through adaptation to unpredictable contingencies (rather than naïve trial-and-error.)¹ The SLC Program promises to add significantly to NSF's ability to create and run increasingly successful, innovative and complex centers.

¹ Cf. Arrow, K. J., 1962, "The Economic Implications of Learning by Doing," *The Review of Economic Studies*, V.29, N.3, pp.155-173; Sheshinski, E., 1967, "Tests of the Learning by Doing Hypothesis," *The Review of Economics and Statistics*, V.49, N.4, pp.568-578.

The challenges inherent in such a program are daunting, and should be recognized in any assessment of progress. They are sometimes easy to miss and might be overlooked. Foremost is the fact that highly educated people, who are nearly always accomplished learners, are prone to think that human learning is well understood. People who are good at learning do not necessarily know how they learn. It is difficult to translate the tacit ability to learn into a mechanistic explanation of how memory and learning are encoded in the biological substrate — or even explain why some methods of teaching work better than others for some people. Paradoxically, humans must make great effort to understand human learning. Nevertheless, that essential challenge is at the heart of the SLC Program. It would be surprising indeed if the program did not encounter impediments and setbacks as it grows, and there have been a few.

It is the view of the COV that impediments and setbacks are inherent in the nature of the challenge undertaken by the SLC Program, and not in the management of the program at the NSF or center levels. The NSF staff and the intellectual leaders at the centers have been diligent, creative and highly dedicated to making the SLC Program a success worthy of the challenges. Moreover, the COV believes that neither the staff at the NSF nor the intellectual leaders in the centers could have foreseen the full costs in time and other resources required to carry out such a challenging program and make it a success. That the program *is* a success speaks volumes about the quality of people involved and the importance to NSF of continuing this effort to learn more about learning and about how to learn.

A final note: The COV template uses the term “evaluation” many times, and this COV struggled initially with interpreting evaluation in light of the successes and challenges faced by the SLC Program. It became clear to us that members of the COV had multiple interpretations of the term. It seemed likely that similar variance in interpretation might be found in the population of readers of this report. For purposes of clarification, we offer this decoding scheme.

- *Evaluation*: a broad term that at heart means “to assign value.” That is, evaluation is undertaken to determine what something is “worth.” Formal program evaluation typically is done, usually infrequently, by supposedly-objective third parties. The COV’s evaluation is not a formal evaluation. The COV judges the SLC Program to be well worth continuing, but the COV’s assessment is not a formal program evaluation. In some ways the term “evaluation” is too broad to be used without calibration in any given instance. The COV envisions the evaluation step as a “benchmarking” process, which allows contextualization of the performance of given SLCs against other SLCs and other center programs in the NSF. We have taken care throughout the body of the report to be explicit about what’s being said.
- *Monitoring*: a narrower term that refers to ongoing and usually close-in observation of routine activity, typically to ensure that operations are going well and near-term scientific, education and managerial objectives are being met. Fundamentally, this should be the traditional “peer review” step of scientific process. Monitoring is often helpful, but it can be intrusive and dysfunctional. The COV has more to say about this in the report.
- *Nurturing*: a term that might embody evaluation and monitoring as mechanisms, but that carries the presumption of a “duty of care” on the part of a principal (in this case, NSF) working with a group of agents (the centers) to accomplish the goals of the SLC Program. Nurturing is essential for any truly successful program, especially one as challenging as the SLC Program. The COV believes that, in some cases, monitoring has impeded nurturing. Again, more is said on this in the report.

The COV appreciates the opportunity to examine this extraordinary and important NSF program. This report concludes with the following recommendations:

- Continue and expand the program
- Do not hold another competition until the results of the current efforts have been more fully assimilated
- Do not merge the SLC Program with other center programs
- Rethink the nature of “evaluation” as applied to SLC Program participants

Respectfully,

The members of the Committee of Visitors
John Leslie King, University of Michigan, Chair
Janis Cannon-Bowers, University of Central Florida
Claudia Carello, University of Connecticut
Laurel Carney, University of Rochester
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**FY 2009 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)**

The table below should be completed by program staff.

Date of COV: March 9-11, 2008
Program: Science of Learning Centers Program
Directorate: NSF Crosscutting Program
Review of Actions from program inception to present, with focus on FY 2006-2008
<p>Awards: 7 Center awards; 4 randomly selected catalyst awards, All Supplements; All workshops; All SGERs;</p> <p>Declinations: 3 randomly selected Cohort One Center declinations, All Cohort Two Center finalists, 4 randomly selected catalyst declinations All supplements; All workshops; All SGERs;</p>
Total number of actions within Program during period under review:
<p>Awards: 74</p> <p>Declinations: 141</p>
<p>Manner in which reviewed actions were selected:</p> <p><i>Reviewed actions were selected based on their occurrence within the time-frame of October 1, 2005 – September 30, 2008 (FY2006-FY2008). Additionally, some actions taken prior to this time have been included after consultation with the COV Chair.</i></p> <p><i>All Center awards, 3 jackets for declinations in competition for Cohort 1 SLCs and all declined finalists for Cohort 2 SLCs will be reviewed. Four randomly selected catalyst awards and 4 randomly selected catalyst declines will be reviewed. All supplements, SGERs and workshop proposal actions will be reviewed. All program actions will be available for review during the COV upon request of a COV member with concurrence of the Chair.</i></p>

PART A. INTEGRITY AND EFFICIENCY OF THE PROGRAM’S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions. Provide comments for those questions that are relevant to the program under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

A.1 Questions about the quality and effectiveness of the program’s use of merit review process. Provide comments in the space below the question. Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE ²
<p>1. Are the review methods (for example, panel, ad hoc, site visits) appropriate?</p> <p>1a. Process for Center selection</p> <p>1b. Process for Center renewal</p> <p>1c. Process for Catalyst awards</p> <p>1d. Process for supplements, SGERs, workshops</p>	<p>Yes; see 1 under 8 below</p> <p>Yes; see 1 under 8 below</p> <p>Yes</p> <p>Yes</p>
<p>2. Are both merit review criteria addressed (in individual reviews, panel summaries, site visit reports, program officer review analyses, as available for each type of review)?</p> <p>2a. Center selection</p> <p>2b. Center renewal</p>	<p>Yes; see 2 under 8 below</p> <p>Yes; see 2 under 8 below</p>

² If “Not Applicable” please explain why in the “Comments” section.

<p>2c. Catalyst awards</p> <p>2d. Supplements, SGERs, workshops</p>	<p>Yes; see 2 under 8 below</p> <p>Yes; see 3 under 8 below</p>
<p>3. Do the individual reviewers (where used) provide substantive comments to explain their assessment of the proposals?</p> <p>Comments: It is preferable for reviewers to go into detail, but not all do. The reviews for this program seem to be in keeping with the norm. NSF staff should continue to encourage reviewers to provide detailed comments for both favorable and unfavorable reviews.</p>	<p>Yes; see comments</p>
<p>4. Do the panel summaries (where panels are used) provide the rationale for the panel consensus (or reasons consensus was not reached)? Site visit reports used in the review process are included under this question.</p> <p>Comments:</p>	<p>Yes</p>
<p>5. Does the documentation in the jacket provide the rationale for the award/decline decision?</p> <p>(Note: Documentation in jacket usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), program officer review analysis, and staff diary notes.)</p> <p>Comments:</p>	<p>Yes</p>
<p>6. Does the documentation to PI provide rationale for the award/decline decision?</p> <p>(Note: Documentation to PI usually includes context statement, individual reviews, panel summary (if applicable), site visit reports (if applicable), and, if not otherwise provided in the panel summary, an explanation from the program officer (written or telephoned with diary note in jacket) of the basis for a declination.)</p> <p>Comments:</p>	<p>Yes</p>

<p>7. Is the time to decision appropriate?</p> <p>(Note that time to decision for full Center proposals is extended due to the use of a multi-stage process including site visits.)</p> <p>Comments: Review of the centers is a complicated process with multiple levels of review and feedback to proposers, which takes a lot of time because the process requires that amount of time. Review of smaller proposals (Catalyst, SGER, Supplement) has been done in a timely fashion.</p>	<p>Yes; see comments</p>
<p>8. Additional comments on the quality and effectiveness of the program's use of merit review process:</p> <p>1. The most unusual feature of the SLC Program is the "center" character. The quality of the research teams that have received awards is very high, but that does not mean the individuals involved know how to run multi-faceted centers that do research, work with practitioners, and perform other important functions. The process for awarding and renewing centers is uneven with respect to evaluating the readiness of the teams to take on the challenges of a center, or to keep a center improving as a center after the award. There are three components of this process: reviews by individuals, judgment by the panel, and judgment by site visitors. The question of readiness for center activity should be emphasized in all three.</p> <p>2. Related to the comment above, there are insufficiently explicit criteria for evaluating what it means to function as a center to guide proposers, reviewers, panelists and site visitors. NSF has had significant experience with centers across directorates, and probably has within it knowledge and resources to develop such criteria and employ them effectively. The COV does not suggest bringing in business consultants for this purpose. The characteristics of NSF-supported centers do not seem to match the characteristics of organizations that business consultants usually work with. This is internal expertise that NSF should grow, marshal, and apply.</p> <p>3. The criteria for evaluating supplements, SGERs, workshops and other proposals related to an SLC should address the connection between the proposal and the SLC. Not all proposals within the science of learning arise in the context of a specific SLC, and those that do not can be handled by normal NSF procedure. However, supplements, SGERs, workshops and similar proposals related to one or more SLCs should be evaluated by criteria that address the relationships.</p>	

A.2 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

<p>SELECTION OF REVIEWERS</p>	<p>YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE³</p>
<p>1. Did the program make use of reviewers, panelists, and site visitors having</p>	<p>Yes</p>

³ If "Not Applicable" please explain why in the "Comments" section.

<p>appropriate expertise and/or qualifications?</p> <p>Comments:</p>	
<p>2. Did the program use reviewers balanced with respect to characteristics such as geography, type of institution, and underrepresented groups? (Note: Demographic data is self reported, with only about 25% of reviewers reporting this information.)</p> <p>Comments:</p>	<p>Yes</p>
<p>3. Did the program recognize and resolve conflicts of interest when appropriate?</p> <p>Comments:</p>	<p>Yes</p>
<p>4. Additional comments on reviewer selection: The issues noted in A.2.1-3 are important, but the background details are not likely to be readily available to members of a COV, even in the best of circumstances. They are embedded in the tacit knowledge of expert NSF program staff. It would be worth some investment of effort for NSF to provide more complete and verifiable summary data on such criteria, benchmarked to other relevant NSF data, so a COV might do a better job of answering the questions. However, the knowledge of NSF experts will remain the primary asset in addressing these challenges, and at best a COV can comment on its confidence that the experts are attending to those responsibilities appropriately. In this case, it seems the experts are doing a good job.</p>	

A.3 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

<p style="text-align: center;">RESULTING PORTFOLIO OF AWARDS</p>	<p style="text-align: center;">YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE⁴</p>
<p>1. Overall quality of the research and/or education projects supported by the program. Comments: A defining feature of the SLC Program is knowledge transfer. This assumes integration of research and practice in the field of learning. This means bridging between fundamental inquiry (e.g., neuroscience, psycholinguistics) and professional practice (e.g., education, robotics). This is desirable, but it is also challenging. The SLC effort is a learning-by-doing project in which challenges are discovered and addressed as the program moves forward.</p> <p>At this point in the program’s evolution, it is unwise to describe progress as “research and/or education” because that question implies that an SLC could be successful being <i>only</i> about research, or <i>only</i> about education. Although centers might be weighted more in one direction or another, in all cases they must move beyond the tradition of simply linking research with graduate training in a manner that nearly all NSF-sponsored projects do. The SLC centers and related awards must bridge between research and education, where “education” is interpreted broadly as knowledge transfer. That bridge might be between research and K-12 education (e.g., PSLC) or between research and industry (e.g., CELEST), but the bridging is a key criterion for evaluation of the SLC Program. The answers to all questions in section A3 are made in the context of this note.</p>	<p>Yes; see comment</p>
<p>2. Is the scope of the projects appropriate for the center form of funding (i.e. size and duration of funding)? Comments:</p>	<p>Yes</p>
<p>3. Does the program portfolio promote the integration of research and education? Comments:</p>	<p>Yes</p>
<p>4. Does the program portfolio include an appropriate complement of:</p>	<p>Yes</p>

⁴ If “Not Applicable” please explain why in the “Comments” section.

<p>Innovative/potentially transformative projects?</p> <p>Comments:</p>	
<p>5. Does the program portfolio include an appropriate complement of: Inter- and Multi- disciplinary projects?</p> <p>Comments:</p>	Yes
<p>6. Do the SLCs involve new investigators in an appropriate way? (Note: A new investigator is an investigator who has not been a PI on a previously funded NSF grant.)</p> <p>Comments: This is an ongoing challenge; the program is doing well with this but adjustment will be necessary over time.</p>	Yes; see comment
<p>7. Do the SLCs demonstrate plans to draw in participants from other geographic regions? Other institutional types? (e.g. through supplements or workshops, etc.)</p> <p>Comments:</p>	Yes
<p>8. Does the program portfolio have an appropriate balance across disciplines and sub disciplines of the activity? Where are the gaps?</p> <p>Comments?</p>	Yes
<p>9. Do the SLCs have appropriate participation of underrepresented groups and/or plans to enhance participation?</p> <p>Comments: The program has been attentive to this, but as with many research endeavors, much remains to be done.</p>	Yes; see comment
<p>10. Is the program relevant to national priorities, agency mission, relevant fields and other consultant needs? Include citations of relevant external reports.</p> <p>Comments: As noted in the cover letter, learning is at the heart of NSF's mission. It is difficult to imagine a more important topic. The field is vast, and could use much greater attention than it has already received.</p>	Yes; see comment

Adjustments to the portfolio will no doubt be useful as the program proceeds, but those adjustments should be grounded in careful examination of what has been learned within and among the centers to date. Workshops would be a good mechanism for pursuing this objective.	
11. Additional Comments on the quality of the projects or the balance of the portfolio: None.	

A.4 Management of the program under review. Please comment on:

PROGRAM MANAGEMENT	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE⁵
<p>1. Management of the program:</p> <p>1a. SLC Program management, including post-award review and management.</p> <p>The conscientious efforts of the SLC staff, including the broad community from across NSF directorates, have been heroic. The challenge of creating the SLC Program is huge and evolving, and this challenge makes management of the program inherently difficult. The fact that NSF experiences attrition as program staff rotate in/out or are reassigned adds to the challenge. The following observations are part of the learning-by-doing process of the SLC Program, and not criticisms of program management.</p> <p>The SLC Program was created without a comprehensive understanding of the amount of effort that would be required by NSF staff to make the program successful. It's doubtful that the effort required could have been foreseen. Most of the NSF staff members who created the SLC Program have moved on, and the current core staff members have been working hard to address the challenges. The team members drawn from across NSF directorates are doing a yeoman's job of seeing the program through. Everyone is struggling to catch up with the effort required. As the program matures it might be possible to focus managerial effort more effectively, as suggested below. But there remains a question as to whether the overall provision of managerial effort is sufficient. This requires attention. As noted earlier, the expertise to address program needs is probably within NSF, but might not have been recognized and marshaled appropriately. Selective use of management consultants might be helpful in drawing that expertise to the foreground and applying it effectively, but it is doubtful that management consultants will themselves be sufficiently expert on the nuances of NSF, the research community, or the centers to find solutions on their own.</p> <p>The NSF SLC management team works closely with center leaders who are themselves learning how to run centers that meet the SLC Program goals. The center leaders occupy two distinct roles that should not be conflated, but that appear to have been conflated in some cases. One is to be an outstanding scholar, capable of leading world-class research in the manner required of most NSF-sponsored projects. The other is that of center manager, doing institution-building. The mechanisms to ensure high-quality scholarship are not the same mechanisms that ensure institution building, and a regimen that works well for one might actually interfere with the other.</p>	

⁵ If "Not Applicable" please explain why in the "Comments" section.

The question cannot be either/or. Both scholarship and institution building are required. The challenge is the balance between the two, especially in the early stages of the SLC Program when everyone involved is trying to determine exactly what constitutes a successful center.

The COV was struck by the intensity and frequency of formal review required of the centers, with annual site visits and other formal reporting mechanisms. At least some of the center leaders complained about this, saying that preparation for and participation in such reviews takes time away from core objectives.

The COV suggests that the SLC Program management experiment with a broader array of mechanisms that can be applied flexibly to address the challenges of monitoring the centers. At early stages, SLC centers might require periodic site visits by teams made of NSF staff and outside reviewers, but this is a heavy-weight mechanism that imposes considerable preparation costs on all involved, and that might not be appropriate for resolving many of the challenges facing centers. Lighter-weight mechanisms such as dyadic or group phone calls or video conferences, center visits by one or two NSF staff members in conjunction with ongoing center activities (e.g., workshops, seminars), and visits by center staff to NSF might be relied on for a greater share of management work going forward. The COV is aware that such mechanisms are already being used, but they appear not to be incorporated as formal components of oversight, accountability and management. The fact that the costs of site visits come from program funds and other costs come from other funds might inappropriately favor site visits. If so, this should be examined and reconsidered.

The COV recognizes that major new initiatives such as the SLC Program require oversight and accountability, given the importance of the focus and the amount of money involved. The question is not whether the program should be overseen and held accountable, but how best to do so given the nature of the program's ambitions and constraints. Most important among these is the emergent nature of the effort to bridge fundamental research with professional practice in the realm of learning. It took many years to evolve mechanisms to do this in the field of health care, and the process is not yet complete. The SLC effort should not be seen as a job to be done in the short-term, but rather as a trajectory of investment and return that will span many years. The best ways to manage this will evolve along with the larger effort, and will be learned and applied as the effort progresses. The COV's suggestion is to put more effort into that process of learning and application.

1b. Management of review processes (pre-award)

With the incorporation of observations about the criteria for readiness related to centers mentioned in A1 above, the management of pre-award review is effective and will become more so as the program matures.

2. Responsiveness of the program to emerging research and education opportunities.

Comments: The management has mechanisms in place for identifying emerging research and education opportunities, and they have been responsive to them. The efforts to evolve the centers as a network, their building of cyberinfrastructure for shared research and data mining, their work with international counterparts, and their emphasis on student interaction across as well as within centers are all examples. Additional opportunities are discussed further in section C below.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Comments: The portfolio was created in major part through the initial solicitation, review and

<p>selection process that led to the awards made to date. This was done well, and that early work continues to shape the program. Further development of the portfolio has been guided by cooperation within NSF, through inter-agency collaboration (e.g. the relationships with NIH and ONR), through liaison work with the EU and other international groups, and through close work with the center leadership.</p>	
<p>4. Did the program create site visit teams balanced with respect to characteristics such as area of expertise, geography, type of institution, and underrepresented groups?</p> <p>Comments:</p>	<p>Yes</p>
<p>5. Did the program recognize and resolve conflicts of interest for potential site visit teams when appropriate?</p> <p>Comments:</p>	<p>Yes</p>
<p>6. Responsiveness of program to previous COV comments and recommendations.</p> <p>Comments: Not applicable, this is the first COV for this program.</p>	
<p>7. Additional comments on program management:</p>	

PART B. RESULTS OF NSF INVESTMENTS

The NSF mission is to:

- promote the progress of science;
- advance national health, prosperity, and welfare; and
- secure the national defense.

To fulfill this mission, NSF has identified four strategic outcome goals: Discovery, Learning, Research Infrastructure, and Stewardship. The COV should look carefully at and comment on (1) noteworthy achievements based on NSF awards; (2) ways in which funded projects have collectively affected progress toward NSF’s mission and strategic outcome goals; and (3) expectations for future performance based on the current set of awards.

NSF investments produce results that appear over time. Consequently, the COV review may include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made.

To assist the COV, NSF staff will provide award “highlights” as well as information about the program and its award portfolio as it relates to the three outcome goals of Discovery, Learning, and Research Infrastructure. The COV is not asked to review accomplishments under Stewardship, as that goal is represented by several annual performance goals and measures that are monitored by

internal working groups that report to NSF senior management.

B. Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes ("highlights") as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

B.1 OUTCOME GOAL for Discovery: *"Foster research that will advance the frontier of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering."*

Comments:

The responses to questions B1, B2 and B3 are all informed by the document titled "Science of Learning Centers (SLC) Program Status Report, FY2006-2008" plus discussions and reading of other documentation. No attempt is made here to recapitulate all of the information available in other reports. Many important contributions to discovery have already emerged from the SLC Program. Some examples include:

Temporal Dynamics of Learning [#0542013, G. Cottrell] The role of timing in children learning to interact with their physical and social worlds has been examined, including how infants discover the presence of a responsive caregiver. A theory of stochastic optimal control allows creation of an artificial system to detect the presence of a responsive individual, perhaps enabling the addition of a "social sonar" to robots such as RUBI, now being tested in classrooms. Such a system could be a huge advance in working with autistic populations that now require intensive one-on-one human interaction to achieve substantial improvements in behavior. Upgrades in the Motion-Capture (Mo-Cap) facility and integration of the Brain Dynamics and Mo-Cap infrastructure enable EEG data to be collected from freely moving individuals, potentially advancing ability to study normal brain function. This is discussed in more detail under B.3, below.

The LIFE Center: Learning in Informal and Formal Environments [#0354453, Bransford] Social interaction is shown to be not only necessary for early learning of a second language, but that the degree of social engagement between a tutor and child predicts the degree of learning. Capture of multi-perspective video records has allowed researchers to understand the types of social interactivity that lead to optimal learning, and new measures of infant social understanding (joint visual attention) have been developed to predict subsequent vocabulary growth. Such studies inform the science and practice of learning and stimulate new experimental design ideas such as videos with mediated human support that may enhance language learning, or "social robots" that test whether social behavior increases learning of a foreign-language in a pre-school setting. An acquired equivalence (AE) paradigm has been used to examine the neurological basis of the learning benefits of "social belief" (i.e., the belief that others were present) to develop preliminary evidence that believing feedback is coming from a person leads to superior transfer (but not initial learning) and higher arousal. Additional background knowledge about others with whom one is interacting has been shown to affect comprehension, memory and communication, reduce cognitive load, and help break through negative stereotypes about others that people have formed.

Visual Language and Visual Learning (VL2) [#0541953, T. Allen] Manipulation of graphic symbols for the expression and reception of linguistic propositions has been shown to be difficult for children; a particularly problematic finding for preschoolers with language impairments who are routinely given arrays of graphic symbols as an alternative form of communication. Overall language ability (including both spoken and signed language) has been shown to be a good predictor of reading ability among deaf readers. Grammatical structure in sign languages is being studied along

with the general domain of gesture in spoken languages to explore the role of imagery in both everyday communication and in learning. A cross-linguistic study of structural complexity in sign language terminology has suggested a continuum of interaction of arbitrariness and iconicity that should have implications for ASL and other signed languages, possibly deepening understanding of language acquisition and the very nature of language.

Center of Excellence for Learning in Education, Science and Technology (CELEST)

[#0354378, S. Grossberg] Synthetic speech sounds from the thoughts of a paralyzed volunteer with locked-in syndrome (full paralysis but conscious) have been created while he imagined producing those sounds. A special electrode implanted into the region of the volunteer's brain controls speech movements, while another system translates neural signals measured from the electrode into the speech sounds being thought of while the electrode measurements are being made. The volunteer's brain signals are recorded to a computer disk and analyzed by the system to reproduce the speech sounds. Implantation of a real-time version of the system is planned that might allow the volunteer to hear the speech sounds immediately upon thinking them.

Spatial Intelligence and Learning Center (SILC) [#0541957, N. Newcombe] A meta-analysis demonstrates the malleability of spatial skills and the importance of spatial training early in a child's educational development, informing ongoing debates about whether spatial skills are fundamentally innate or can be trained. Behavioral experiments show the role of hand gestures in children's spatial thinking and in subsequent language development. Improvements in mental rotation skills through training in the use of gestures suggests that hand gestures are an unexpectedly powerful mechanism for training spatial skills.

Center on Mathematics and Deaf and Hard-of-Hearing Learners (Catalyst) [#0350277, R. Kelly]

Deaf learners at middle school, high school, and college levels of education were shown to understand the fundamental meaning of universal quantifier sentences, but differed from hearing native speakers in their knowledge of or preferences for specific interpretations. Differences were explained in terms of the influence of economy principles associated with minimalism on language acquisition and aspects of semantic complexity, with implications for understanding of language acquisition under conditions of restricted access to spoken language input, as well as to language acquisition generally.

B.2 OUTCOME GOAL for Learning : *“Cultivate a world class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens”*

Comments:

Center of Excellence for Learning in Education, Science and Technology (CELEST)

[#0354378, S. Grossberg] CELEST organized the first annual Inter-Science of Learning Centers Meeting (iSLC) brought together 121 students and post-doctoral fellows from various Centers to learn about different approaches and ideas in the field of learning sciences. The meeting was planned and organized by six students and post-docs from current Science of Learning Centers, and included seven students from international groups working on learning science research. The meeting leveraged the strengths of the individual Centers to create a synergistic body of knowledge and methodologies that can help form a bridge between the science of learning and the practice and art of learning. The three day conference was highlighted by poster sessions, scientific symposia, professional development workshops, administrative breakouts, methodology workshops, and many opportunities for informal discussion and learning. Organizers hope to create a network of Centers where researchers approach the science of learning with open minds and appreciation for the interdisciplinary nature and different approaches needed for studying learning.

Pittsburgh Science of Learning Center (PSCL) (#0354420, Koedinger) The Physics LearnLab Course (PLLC) permits the study of how students learn introductory physics, providing baseline data on student activities throughout the physics course and hosting specific research studies that measure the improvement in students' learning caused by changes in the instruction. PLLC is used in the Introductory Physics courses at the US Naval Academy in Annapolis, MD and three courses at Watchung Hills Regional High School in Warren, NJ, with additional sites at both high school and university level in development. Students use the Andes intelligent tutor to do their homework, allowing PLLC to collect fine-grained data on student activity through the entire semester. In vivo experiments modify Andes or run studies during lab sessions that instructors have "donated" to the PLLC. The number of Andes problems assigned by instructors at the Naval Academy increased from 58% to 100% in the Fall semester, and from 42% to 75% in the Spring semester. The total number of Andes problems has grown from 350 to 556, the number of physics principles has increased from 126 to 219, and the number of rules in the physics "Knowledge Base" has increased from 619 to 915. PLLC allows physics teachers to achieve instructional goals develop better instructional methods. Use of Andes for homework allows instructors to spend less class time on the "mechanics" of solving problems and more time on discussion conceptual issues. Students talk of solving problems "Andes-style," meaning careful attention to drawing diagrams, defining variables, and showing work.

Visual Language and Visual Learning (VL2) (#0541953, T. Allen) Current education practices with deaf and hard of hearing students do not lead to academic skills similar to hearing peers. Cognitive and pedagogical theories based on the typical "hearing" English-based environment are insufficient for understanding alternative pathways to achieve effective cognitive abilities amongst deaf and hearing students. Improved reading instruction leading to optimum results among deaf students could provide levels of literacy necessary to include this population in science and engineering. An innovative journal in video format keeps students informed and provides them improved communication with other stakeholders in their education.

Spatial Intelligence and Learning Center (SILC) (#0541957, N. Newcombe) SILC has hosted speaker-series on spatial learning in Chicago and Philadelphia, matched by an extensive conference series on spatial learning in Pittsburgh and a presentation in Freiburg. The Center is sharing results of research with teachers in the Chicago Public Schools through Teacher Work Circles focused on relevant spatial topics in STEM disciplines. Key concepts/ skills have been developed for children with *sustained* difficulties. Specific recommendations have been provided to improve children's learning of the targeted concepts/skills.

Temporal Dynamics of Learning Center (TDLC) (#0542013, G. Cottrell) Center participants have developed a program that includes the development of testbeds for experiments at the Preuss School and the Early Childhood Education Center. New vehicles for dissemination of research results have been developed, including lectures for teachers, posting of progress reports regarding collaboration in TSN, presentation of papers at major neuroscience conferences, and implementation of research in the design of technology. The centerpiece of the effort, a Network of Networks, provides a new collaborative research structure to transform the practice of science building on the success of the Perceptual Expertise Network (PEN). This will create a new overarching structure to coordinate activities across networks engaged in a common scientific inquiry.

Learning in Informal and Formal Environments (LIFE) (#0354453, Bransford) LIFE researchers have given presentations, led workshops, and engaged in organized discussions with parents, principals, policy makers, teachers, after school mentors, and other researchers. They have worked with colleagues in Japan, Jordan, Singapore, Sweden, Finland, Costa Rica, and several other Latin

America countries, and with Microsoft's International "Innovative Schools" program involving collaboration among school systems from around the world. They were active in planning the International Society of the Learning Sciences (ISLS) conference in 2008. New courses have been created and the internship program has grown to allow graduate students from several universities to collaborations that will last beyond the internship experience. Graduate students are playing leadership roles, leading or planning workshops at scientific conferences. The Student Leadership Group has planned cross-SLC student events. The Diversity Task Force and members of the Student Leadership Group have developed a sequence of educational activities focused on issues of diversity within the research portfolio, with shared readings and collective discussions of future research plans that focus on diversity issues. A consensus report, *Learning In and Out of School in Diverse Communities: Life-long, life-wide, and life-deep*, delineating research principles associated with learning in diverse communities was distributed to hundreds of scientists and educators in hardcopy, and over 12,000 copies have been downloaded from the web. A policy version of the report is for use with policy-makers has been prepared.

Center for Excellence in Adaptive Neuro-Biomechatronic Systems (Catalyst) [#0518697, R. Jung] A mini-symposium and workshop on "Adaptation and Learning in Neuro-Biomechatronic Systems" was attended by faculty, students and researchers from engineering, life science, and liberal arts departments at Arizona State University as well as Metropolitan Phoenix clinical institutes. Distinguished speakers presented seminars at the symposium, and a related workshop was attended by over 20 participants to discuss plasticity and learning in both living and artificial systems. In-depth discussions identified strengths and gaps in the vision behind the catalyst grant, and strategies were developed to link basic science and technology development for co-adaptive learning with a closed-loop between humans and technology. Further exploration was targeted on neural plasticity from the cellular to the network level and on smart algorithms and adaptive hardware.

Center of Excellence for Learning in Education, Science and Technology (CELES); Supplement award #0631545 [#0354378, S. Grossberg] A conference on cognitive and neural systems was held at Boston University, sponsored by the Boston University Center for Adaptive Systems and the Department of Cognitive and Neural Systems, focused on the questions "How does the brain control behavior?" and "How can technology influence biological intelligence?" The conference was attended by researchers and students of computational neuroscience, cognitive science, neural networks, neuromorphic engineering, and artificial intelligence, and included invited lectures, contributed lectures, and posters by experts on the biology and technology of adaptation by the brain and other intelligent systems in a changing world.

B. 3 OUTCOME GOAL for Research Infrastructure: *"Build the nation's research capability through critical investments in advanced instrumentation, facilities, cyber-infrastructure and experimental tools"*

Comments:

Pittsburgh Science of Learning Center (PSLC) [#0354420, K. Koedinger] A novel approach to enhancing research infrastructure uses a method called *in vivo* experimentation to focus on the causes and effects of robust learning. This infrastructure called LearnLab includes seven technology-enhanced and instrumented math, science, and language courses taught at multiple high school and/or college sites. Data are stored in PSLC's open data repository, the DataShop, another contribution to research infrastructure that makes available fine-grain longitudinal records of student learning interactions, and provides data visualizations, data mining algorithms, and data consulting. Also available are technologies for analyzing verbal data and for authoring of cognitive tutoring systems, dialog-based tutors, reading tutors, and models of student learning. Researchers have

completed 138 tightly controlled LearnLab experiments in real high school and college classes, including data from students engaged in real courses, with over 63,000 hours of human learning data. This is like a high speed research highway to move investigations effectively and efficiently.

Spatial Intelligence and Learning Center (SILC) [#0541957, N. Newcombe] SILC has used cyberinfrastructure to run virtual lab meetings for students on two campuses separated geographically. Students share laboratory work over the Internet and meet via conference calls to discuss findings. A webpage and a shared Spatial wiki network have been created that include bibliographies, lists of organizations that share an interest in spatial learning, announcements of relevant national and local meetings and conferences, and research materials such as tests, stimuli, and questionnaires. SILC is also using eye-tracking systems to measure eye-movements in research subjects who are presented with exercises that engage their spatial understanding.

Center of Excellence for Learning in Education, Science and Technology (CELEST); [#0354378, S. Grossberg] CELEST is developing modules for use in classrooms at middle school through undergraduate levels. Modules contain teacher instructions, class presentations, background and theory, software user's guides, classroom materials and neural network models for advanced studies. Specialized modules include *Brightness Lab* that teaches students about how we see bright and dark surfaces, *Sequence Learning* that teaches the basis of time sequencing found in various information processing tasks during learning, *Associative Learning* that uses eye-blink conditioning to develop an understanding of types of memory, *Recognition* teaches how humans and machines learn to recognize objects and events, and *Obstacle Avoidance* that explores human navigation in the world using 3D interactive software.

Center of Excellence for Learning in Education, Science and Technology (CELEST) [#0354378, S. Grossberg] The Neurala Technology Platform (NTP) exploits low-cost parallel hardware components to implement biologically inspired neural models. It accelerates computationally intensive algorithms without requiring customized code for parallel processor hardware. It is used to study automatic classification and information fusion that rely heavily on Artificial Intelligence (AI) and are expected to have a major impact on remote sensing. Feature extractions and classification benefits from NTP tools for writing elementary operations of algorithms in parallel form. It is currently used for detection of signature characteristics of wildfires, where real-time output can be used to forecast occurrence and direction, facilitating a prompt intervention.

Temporal Dynamics of Learning Center (TDLC) [#0542013, G. Cottrell] The Brain Dynamics Facility enables accurate measurement and analysis of whole-brain activity using an approach combining temporal resolution of EEG and spatial resolution of fMRI together with advanced data analysis and software tools. Combined with single-cell recording equipment and the Motion Capture Facility the Brain Dynamics Facility enables simultaneous recording of brain activity and complex motor behavior for understanding spatio-temporal changes in brain dynamics that underlie the process of learning. The Motion Capture Facility has state-of-the-art equipment for marker-based motion capture, high-speed video recording, eye tracking, hand tracking, muscle recording. It provides a range of devices for tracking behavior, including hand movements, eye movements, full-body movements, facial expressions and inter-personal interactions. Stimuli can be tightly coupled with observed behaviors to allow researchers to manipulate time and timing, investigating their role in learning and in the development of adaptive behavior. It has integrated brain dynamics with state-of-the-art motion capture.

Visual Language and Visual Learning (VL2) [#0541953, T. Allen] "Best practice" ethical and scientific standards for video-based research in visual communication have been developed to protect participant confidentiality. International metadata standards for sign language research have been developed to make databases searchable and accessible to researchers within and outside

VL2. The “VL2 Toolkit” has been created, a suite of technologies and instruments for assessing American Sign Language skills and to investigate the impact of visual language acquisition on cognitive development and reading achievement. The toolkit enables standardized research protocols to investigate the effects of visual language on learning, development, and cognition, and to compare results across studies within deaf research and education communities. A network of educational centers for outreach is already in place.

PART C. OTHER TOPICS

C.1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

As noted earlier, the importance of any proposed center to function as a center should be incorporated in pre-award evaluation. It would be helpful to incorporate people with experience in running research centers on panels. The workload on the rotating staff is significant. They are typically asked to contribute to the SLC Program on top of their normal workloads. One way of addressing this would be to work with managers in other NSF areas to incorporate SLC Program work in the normal workload. Another might be to add permanent staff to the mix of permanent and rotating staff.

C.2. Please provide comments as appropriate on the program’s performance in meeting program-specific goals and objectives that are not covered by the above questions.

As noted in the cover letter, the SLC Program treats centers as nodes in an expanding network, a growing community of practice focused on the science of learning. This is an innovative and important contribution to the program’s performance in meeting the extraordinary challenges it faces, and adds greatly to the program’s overall contributions.

C.3. Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

As noted in C.1 above, the burden of the SLC Program on the broader NSF community workload should be addressed. It is also the view of the COV that NSF probably has more expertise in running such complicated endeavors, but is not drawing on that expertise as much as it might because that expertise is tacit within the Foundation. Deliberate efforts to make NSF more of a “learning organization” in this regard would be a good investment. It is especially important for NSF to become more expert in gauging the amount of effort that will be required to succeed at innovative programs such as the SLC Program. This means investing the right amount of the right kinds of effort. It also means knowing where that effort is best applied. A particular concern of the COV at this time is the degree to which the centers are subjected to intensive and, possibly, intrusive monitoring. A rebalancing of evaluation, monitoring and nurturing seems in order. The COV understands that frequent site visits and other mechanisms of examination that preoccupy the leadership of the SLC Program (both at NSF and the centers themselves) might be part of a broader scheme for keeping track of center programs eventually. If so, the overall scheme should be examined.

The COV feels that the annual site visits for the SLC centers take an extraordinary amount of time, and appear to be disruptive to the important work of the centers. The alternative is not to leave the centers alone to do what they wish; the program is still evolving and requires constructive monitoring and nurturing. Thus the idea of “rebalancing.”

It was mentioned in the course of the COV meetings that the possibility of merging the SLC Program with existing center programs (e.g. the STC or ERC programs) is being considered. The COV recommends strongly *against* such a merger. The SLC Program has special and valuable characteristics not seen in the other center programs, and these would easily be lost if the SLC Program were merged with programs that have been around longer and have a more established history. The COV does recommend more Foundation-wide examination of how best to run center-related programs to capture expertise that relates to such programs.

Finally, the COV was puzzled to learn that recommendations made by the SLC NSF staff, following procedures incorporating site visits, were altered at the National Science Board. However, no information was made available for the COV to interpret these actions. The COV acknowledges the role of the NSB and the Board's prerogative to make adjustments in programs as necessary. However, it was difficult for this COV to incorporate the fact of those changes into its deliberations without understanding why the changes were made. Some thought should be given to providing COVs with such information to help them in their mandate to comment on the processes and results of given programs.

C.4. Please provide comments on any other issues the COV feels are relevant.

See cover letter and additional questions below.

C.5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

This was an unusual COV, so it is not clear whether the experience of this COV is exemplary. Some members of the COV were confused about what to expect in the way of information for study in advance. It would have been helpful for some to have such information in advance, but it is recognized that confidentiality or other factors might restrict what can be made available. Given the mass of information available on each of the centers, it is no surprise that some useful information did not make it into the eJacket folders (e.g., center evaluations). The COV received such information on request from the NSF staff, but it would have been helpful if all such information was in the eJacket in the first place. With so much information available, it was not always clear what information was essential and what was not.

The COV template provided did not apply very well to the charge for this COV: perhaps more than one template might be developed to allow more precise selection for given applications.

Finally, it would have been helpful to receive more reflection from PIs in the centers on how their understanding of the center concept has changed, how their center has evolved, and what they've learned along the way.

Additional SLC Questions:

- 1. Based on the presentations, your reading of the Center documentation, and the information about supplements, workshops, etc., what evidence do you see of the Centers leveraging their relationships with the SLC Program, with one another and with the nascent network of Centers? To what extent is this adding value to their ability to meet their own Center-based goals and results?**

Each of the centers in the first cohort has had to address the challenge of defining what an SLC center should be, how it should operate, and how it should interact with NSF and other centers. In many ways, simply succeeding as centers has been the primary goal, and the question of leverage over and above

this goal must be seen in the context of the challenge. There is considerable evidence in the site visit documents and correspondence between the NSF program leaders and the center leaders that a great deal of learning has been going on with regard to the challenge. For example, the ongoing conversations among NSF program leaders, center leaders and outside evaluators (e.g., site visit members) document many instances in which given projects or programs within the centers are encouraged to add specific capabilities (e.g., more expertise in social psychology) or to open new lines of inquiry (e.g., bring in a neuroscience component). This is clearly a form of leveraging relationships within the SLC Program. There has also been considerable discussion regarding administrative issues, and a number of difficulties have been overcome through collaborative action. This early learning has helped the second cohort of centers move more quickly on both research and administrative matters.

Another important form of leveraging has been among the center participants themselves, both within the centers and across the centers. This shows up in supplement awards (e.g., supplement #0732182 for collaboration between VL2 and PSLC), the growing network collaborations such as the meeting that brought together over 120 doctoral students and postdocs from across the centers (#0354378), and the evolving PI meetings. An important part of this leverage, albeit a part that is probably too embedded in routine use to be readily observable, is the embrace of cyberinfrastructure for routine collaboration among students.

2. Is there evidence of new research paradigms, organizational structures, or intellectual structures are emerging from the work of the Program or the Centers? If so, are there any observations you can make about the impacts on the culture of research and research transfer for learning and education?

It is a bit early to expect the emergence of new research paradigms, but there is promise that new paradigms will emerge. For example, work by VL2 is creating a large corpus of video data that can be used by all members of the SLC community to examine special cases of learning – in the case of VL2, language acquisition among the deaf. There is good reason to hope for significant innovation among and across the centers as participants gain skill in collaboration. These are likely to produce new intellectual structures as they progress. New organizational structures are already emerging as the concept of centers as nodes in a network takes form. As suggested above, the centers are emerging as a learning community at least with respect to student engagements. We would hope that they are also sharing problems and solutions related to their emerging roles as centers. In a way, the SLC centers are serving as a microcosm of a larger challenge of learning improvement, which concerns the formation and maintenance of learning communities.

The SLC Program is special in that it is a deliberate effort to create and sustain a particular kind of learning community focused on learning itself. Moreover, unlike other programs supporting individual investigators or centers that operate as local silos (albeit linked through pre-existing scholarly networks), the SLC Program envisions new networks as a means of bringing the larger SLC community together and expanding the community beyond the boundaries of the centers themselves.

Catalysts, SGER and Supplemental awards are being used to bridge sub-communities in the process of building a larger community. For example, a supplement award (#7032182) has been used to build collaboration between VL2 and the PSLC. This is essential for the growth of interdisciplinary research as well as for bridging communities of research and communities of practice that is at the heart of the SLC Program vision. It is difficult work, and should not be expected to happen overnight. It requires realignment of basic assumptions about community (e.g., who is “inside” and who is “outside”) as well as changes in deeply held incentive and reward structures. Doing it right is a long-term investment in the national capacity to innovate. As the students involved in the centers network among students from other centers, they build ties that will sustain the field in the future.

3. What observations do you have regarding the role of external evaluation in improving Center performance?

Evaluation of the SLC Program is vital to the learning-by-doing process because it establishes and reinforces reflective practice. It is also required to assure NSF sponsors that progress is being made. As noted in the cover letter and above, the COV is concerned that the SLC Program is monitored in ways that might be dysfunctional for both of these objectives. The SLC Program needs some adjustment in terms of evaluation, monitoring and nurturing. The center leadership and the NSF program leadership at times appear to be trying to meet monitoring requirements at the cost of important programmatic work. The SLC Program has made extensive use of costly annual site visits when lighter-weight mechanisms might work as well and be less burdensome to all concerned. The cadence of learning-by-doing has a natural pace in emerging enterprises, and it is risky to push that pace faster than it can go. Frustration with challenges in the early days of the SLC centers understandably leads to calls for more oversight, often resulting in even more intrusive monitoring. If challenges to the centers or to the program are due in major part to the inherent difficulty of the venture itself, and not to performance failures of the participants, intrusive monitoring can pull attention away from meeting those challenges.

The SLC Program addresses a vitally important set of national needs, and is making good progress in the face of difficult challenges. More intrusive monitoring will not accelerate that progress. In the spirit of learning-by-doing that embodies the SLC Program, the mechanisms of evaluation, monitoring and nurturing should evolve with the program.

4. NSF is currently planning an external evaluation of the SLC Program. What guidance can you provide on the most appropriate areas of focus for the external evaluation? What types of data might best enable such a focus?

As NSF prepares for such an evaluation, it should consider carefully the cost to the SLC Program team to get ready for and participate in an evaluation while trying to address the many challenges facing the program at this time. Rather than just evaluating the SLC Program, it might make sense for NSF to invest in a broader evaluation of center programs generally. The STC and ERC programs have been going for some time, and there has undoubtedly been a great deal of learning among those centers, and that learning should be captured for use across all center efforts. The COV has the impression that early STC and ERC program efforts resemble early SLC Program efforts, suggesting that the SLC Program might not be much different in some respects than those center programs, and further suggesting that experience from those programs would benefit the SLC Program.

The COV also has the impression that the SLC Program differs from the STC and ERC programs in key ways, and that these differences might provide the opportunity for SLC experiences to be helpful to STC and ERC efforts over time. As noted earlier, in addition to the special focus of the SLC Program on learning – itself a daunting challenge – the SLC scheme itself embodies the idea of networked learning communities not found at the core of either the STC or ERC programs. The major virtue of an all-center evaluation is the ability to contrast the particular objectives and circumstances of each kind of center with the broad general objectives of centers. This contrast would be most useful in helping to discriminate between inherent challenges that require significant effort to overcome and particular challenges that might be addressed by specific changes in management or project within one program.

5. Please provide any comments you may have on the SLC management model, including the roles of the SLC Program officers, the SLC Coordinating Committee, and the technical coordinators.

The SLC management model seems effective overall. The SLC Program officers, coordinating committee members, and technical coordinators appear to be working very hard to keep the program on track. As noted earlier, the SLC Program appears to be more demanding than some of those involved in its creation originally imagined. It would be best at this time to avoid over-burdening program management with additional requirements and expectations. Rather, the best strategy would be to let the workload of the program and the capacity of the program management come into equilibrium for a while so that the program can mature and the benefits of learning-by-doing can be captured.

6. What recommendations can you make to improve the program, particularly with respect to leveraging NSF's own learning about research and education as a result of the program?

The SLC Program is in good condition, despite its ambitious agenda. The program should be given time to consolidate what it has accomplished and to develop the means to exploit that knowledge. Toward this end, the COV recommends against further burdening the program with a new competition that would be better off held after the current centers have settled down. The COV also recommends strongly against merging the SLC Program with other center programs. While there are similarities among center programs, as noted above, there are also important and constructive differences between them. Merging the SLC Program with another, more-established center program would likely retard growth of special SLC characteristics, and possibly damage subtle and valuable aspects of the SLC Program.

SIGNATURE BLOCK:

For the Science of Learning Centers Program COV

A handwritten signature in black ink, appearing to read 'JLK', with a long horizontal stroke extending to the right.

John Leslie King, Chair