

Review of the Center for Mathematics, Science, and Technology

Classification of Instructional Programs (CIP) Code: 90.1313

Research and Service Center: Teacher Education and Professional Development, Specific Subject Areas

The Center for Mathematics, Science, and Technology (CeMaST) was established in 1991 to promote integrating and improving the teaching and learning of science, technology, and mathematics for students across the K-12 and undergraduate spectra. The Illinois Board of Higher Education (IBHE) authorized CeMaST as a temporary research and service center in 1992 and then as a permanent center in 1997. This is the fourth review of the center since its inception. In its 25 years of service to Illinois State University, CeMaST has led major curriculum and professional development projects in the STEM fields (science, technology, engineering, and mathematics) at the University. CeMaST has also made significant contributions to STEM education on the state and national levels.

CeMaST supports research and service in STEM education in three ways. Some CeMaST initiatives are almost exclusively driven by center faculty and staff, some are implemented through partnerships between CeMaST personnel and other faculty and staff at the University, and some are broad partnerships in which CeMaST assumes a peripheral role. Much of the research sponsored or assisted by CeMaST through these three approaches is conducted by faculty members at the University known as CeMaST fellows. Fellows are based in academic units at the University and conduct research in STEM education through projects sponsored or facilitated by CeMaST. At the time of this center review there are more than 40 CeMaST fellows from 12 departments or schools at the University.

CeMaST reports to the Associate Vice President for Research and Graduate Studies in the Office of the Provost. Center initiatives are coordinated by a management team comprised of the director, four associate directors, and an assistant director. Associate directors represent the College of Applied Science and Technology, the College of Arts and Sciences, and the College of Education. A key role of the associate directors is to extend the reach of the center into their respective colleges.

The current iteration of the CeMaST mission is “to stimulate, conduct, and support integrative science, technology, engineering, and mathematics (STEM) education activities and scholarship.” Three goals emanate from the mission: to stimulate and support activities and research on teaching and learning that align with campus, state, and national STEM priorities; to provide leadership to and foster cross-disciplinary collaborative STEM activities and research on teaching and learning; and to direct efforts to increase the diversity of STEM communities through innovative programming, partnerships, and outreach.

EXECUTIVE SUMMARY PROGRAM REVIEW SELF-STUDY REPORT

Self-study process. Self-study has been an ongoing process for CeMaST since the last center review in 2011-2012. At that time CeMaST had just compiled a new assessment plan. The center has since implemented the plan by regularly collecting data related to performance of the center with respect to its goals. Every year a meeting of the management team is held to determine the extent to which the assessment data compiled that year accurately reflect what occurred that year and the extent to which satisfactory progress has been made toward meeting center goals. For this center review the management team held a series of three meetings in spring 2015 in which annual data for the preceding three years were examined goal by goal. The center director took the lead compiling data and drafting the self-study report. In September 2015 the management team reviewed the report for accuracy prior to its submission.

Assessment. As noted in the discussion of the self-study process, CeMaST has an extensive plan for assessing center progress toward meeting its goals. For each goal the center has identified outcome measures, data to be collected and analyzed, benchmarks, and a timeline for data collection. Data are reviewed annually by the management team to assess progress toward meeting the goals. Based on the annual review, existing center initiatives may be modified and priorities for new initiatives may be established.

Accomplishments. During the last four years CeMaST has continued its efforts to encourage STEM teaching and learning throughout the state and nation. CeMaST has sought external funds for these efforts and has been successful in doing so. Twelve STEM education projects were implemented almost exclusively by CeMaST faculty and staff during the review period, valued at approximately \$7 million. Eight projects were implemented collaboratively with other faculty during the review period, valued at approximately \$4.5 million. CeMaST had peripheral involvement in two projects during the review period, valued at approximately \$20 million.

Major initiatives of the center in the last four years include Engineering K12 STEM Education, STEM Teacher Professional Development, and Urban STEM Ed. The **Engineering K12 STEM Education** initiative aims to drive the national discussion towards embracing the role of engineering education and integrated STEM education in K-12 schools. Through this initiative CeMaST has researched and developed new integrated STEM curricula for elementary education. The center has published student and teacher editions of its *Creative Core Curriculum: Mathematics with Literacy and STEM* for grades kindergarten through eight. The center also has published student and teacher editions of its *Creative Science Curriculum with STEM, Literary and Art* for grades kindergarten through five. CeMaST has worked toward adoption of the curricula by school districts across the country. As of summer 2015, the curricula had been adopted by six states: California, Florida, Georgia, New York, North Carolina, and Texas. **STEM Teacher Professional Development** aims to help teachers across the country implement Next Generation Science Standards and Common Core State Standards for Mathematics and to integrate STEM practices and experiences into the local curriculum. Since 2011 CeMaST has trained over 2,500 teachers across the K-12 spectrum nationally. Through **Urban STEM-Ed**, CeMaST is working to integrate STEM disciplines into initiatives of the Chicago Teacher Education Pipeline project sponsored by the College of Education. The Pipeline project aims to document steps taken by Illinois State to become an urban-serving institution based in a non-urban environment. Contributions of CeMaST to this effort include support for STEM scholarships and assistance developing relationships with schools in Chicago, Rockford, Peoria, and Decatur.

CeMaST has been involved in numerous efforts to outreach to the campus, local community, and region to encourage STEM teaching and learning. Examples of these CeMaST efforts include hosting the annual high school research symposium that has attracted 1,200 students over the last five years, organizing the annual Illinois Summer Research Academy that has involved 250 high schools students over the last five years, and organizing the annual Family Science Day at Illinois State, which attracts between 2,000 and 4,000 attendees each year.

A major effort of CeMaST and the faculty with whom CeMaST collaborates is communication of STEM research findings and their applications to practice. During the last four years 74 publications have resulted from CeMaST projects, including peer-reviewed manuscripts, monographs, and curriculum textbooks. In addition, the center has brought several STEM journals to Illinois State, where they are compiled, edited, and published. STEM journals now housed at Illinois State include *Illinois Technology Education*, *Journal of Physics Teacher Education Online*, *Journal of Technology Education*, *Journal for Research in Mathematics Education*, and *Journal of STEM Teacher Education*.

Resources. The Office of the Provost annually allocates approximately \$400,000 to CeMaST in general revenue and in-kind services for personnel, office space, and operating expenses. Most of this contribution is used by CeMaST to cover salaries and benefits for four full-time-equivalent positions including the full-time center director, two full-time support staff, and four quarter-time associate directors. CeMaST staff hired with the funds seeks external funding for research, services, and other initiatives of the center. At the time of this review CeMaST organizes, manages, or serves as fiscal agent for nine external grants with a total value of approximately \$5 million. Three ratios can be used to describe the extent of external funding received by CeMaST. For projects led almost exclusively by CeMaST personnel, the external-to-internal funding ratio is approximately 4 to 1. For collaborative projects involving CeMaST and other faculty at the University, including CeMaST fellows, the ratio is approximately 3 to 1. For projects in which CeMaST assumes a peripheral role, the ratio is approximately 12 to 1. With the publication of core curriculum materials in 2012 and 2013, the center can potentially generate revenue in coming years through sale and licensing of them.

Response to previous program review recommendations. Five recommendations from the Academic Planning Committee resulted from the 2011-2012 CeMaST center review. The Academic Planning Committee recommended that CeMaST implement its new assessment plan and adjust center goals and initiatives as needed based on assessment results. The CeMaST management team has done that. Each year the team collects and analyzes data per

the processes set forth in the 2011 assessment plan and then meets to discuss progress toward center goals. The Academic Planning Committee recommended that the management team compare the center to national or international benchmark STEM education research centers to identify actions CeMaST might take to meet or exceed levels of quality at those centers. As part of the center self-study the management team conducted an analysis of STEM education centers regionally and nationally to determine the impact of CeMaST on STEM education relative to the impact of other STEM education centers. The Academic Planning Committee recommended that CeMaST continue to seek external funds to support its mission and goals. Since the previous center review CeMaST has been involved in 22 newly-funded projects in addition to 13 grant-funded projects that had been awarded prior to 2011. The center submitted 12 other external funding requests that were declined, but some of the declined requests were subsequently resubmitted and awarded. The Academic Planning Committee recommended that CeMaST continue its efforts to build a STEM education community at Illinois State through collaboration with faculty, staff, and students in STEM disciplines. CeMaST has done so, with the three associate directors of the center helping make connections in their respective colleges. More than 40 faculty members from 12 departments or schools at the University now serve as CeMaST fellows. The Academic Planning Committee asked CeMaST to consider establishing an advisory board of external stakeholders to provide ongoing input and feedback regarding center initiatives. The CeMaST management team discussed the idea but decided not to pursue it because of the funds staff felt would be needed to establish such a board in a meaningful way (e.g., for travel, lodging, and board member stipends).

Major findings of this self-study. During the last four years CeMaST has continued to play a significant leadership role in STEM education in the state and nation. Development of integrated STEM curricula for elementary education, collectively known as the *Creative Core Curriculum*, is a significant accomplishment of the center since 2011 and has been recognized as exemplary by the National Academies of Engineering. CeMaST has also been involved in a variety of other innovative projects and programs since the last center review. On the state level, for example, CeMaST has sponsored the Illinois Summer Research Academy for high school students and has developed a network of more than 800 mathematics and science teachers across the state participating in STEM education initiatives. To support these initiatives the center has been successful in obtaining external grant funds. The ratio of external grant funds awarded to the center to funds invested in the center by the University is highly favorable. Likewise, the numbers of programs administered by the center, publications resulting from center sponsored or assisted research, and teachers and students involved in STEM education activities are also highly favorable. CeMaST has particularly had a high rate of success securing grant funds from the U.S. Department of Education/Illinois State Board of Education Mathematics Science Partnership for teacher development workshops. However, with drastic changes to that program likely in the coming years, the center needs to identify new funding opportunities. As external funding of the center has fluctuated, the numbers and types of initiatives offered by the center, and the staff resources available to implement them, have also fluctuated. This phenomenon is likely to continue through the next center review cycle as state and federal funding priorities and funding levels continue to change. One constant amid these changes has been the high quality of CeMaST programs and services due largely to the expertise and dedication of center faculty, staff, and fellows.

Initiatives and plans for the next program review cycle. Based on findings of this self-study, CeMaST has identified five priority initiatives for the coming review cycle: CeMaST should focus on increasing adoption rates for its *Creative Core Curriculum* rather than resurrect and rewrite its middle school STEM curriculum (known as IMaST or Integrated Mathematics, Science and Technology) developed by CeMaST over the first 10 years of its existence; CeMaST should continue to explore new opportunities for external funding from foundations, industry, and other agencies; CeMaST should consider extending its work in STEM education into postsecondary education, investigating the undergraduate STEM education niche for the center and ways the center can play a strong and meaningful role in STEM education of undergraduate students at Illinois State; CeMaST should continue to support faculty and staff across the University with STEM education; and CeMaST should continue to develop its local, regional, and national leadership roles in STEM education.

PROGRAM REVIEW OUTCOME AND RECOMMENDATIONS FROM THE ACADEMIC PLANNING COMMITTEE

The Academic Planning Committee, as a result of this review process, finds the Center for Mathematics, Science, and Technology (CeMaST) to be in Good Standing.

The Academic Planning Committee thanks CeMaST for a concise yet critical and forward-looking self-study report. The report appropriately and clearly distinguishes initiatives undertaken by CeMaST from initiatives facilitated or encouraged by center staff but implemented by others. The report evidences involvement by multiple stakeholders in the review process and also evidences integration of program evaluation, including the center review process, in the ongoing work of the center. The committee acknowledges and thanks the center for its responsiveness to recommendations resulting from the last center review in 2011-2012.

The committee commends the center for its leadership in promoting quality instruction in STEM disciplines (science, technology, engineering, and mathematics) at the elementary and secondary education levels. Through this leadership the center continues to further the *Illinois Public Agenda* (the strategic plan for higher education in the state) and its goal of increasing educational attainment among Illinois residents. The center is also a leading contributor to STEM education nationally. The center has developed the *Creative Core Curriculum*, which integrates STEM education in elementary and secondary curricula from kindergarten through tenth grade, and has trained teachers and administrators nationwide in use of the curriculum. As of fall 2015, the core curriculum had been adopted in six states: California, Florida, Georgia, New York, North Carolina, and Texas. Approximately 2,500 teachers across the nation have participated in STEM professional development opportunities offered by the center since 2011.

The committee commends the center for its numerous efforts to outreach to the local community and beyond. The center annually sponsors the Illinois Summer Research Academy and Family Science Day on campus. The center also works to extend quality STEM education to students enrolled in diverse urban schools, particularly students of color, in other areas of the state through collaboration with initiatives such as the Chicago Teacher Education Pipeline.

The committee recognizes the center for its involvement of faculty from numerous units across the University in STEM research and in dissemination of research findings through publications and presentations. These efforts help inform STEM education practices across the state and nation. The committee also recognizes involvement by the center in hosting five STEM education journals at the University.

The committee commends the center for continued diversification of its revenue sources through procurement of federal and state grants and through income generated from center publications and professional development offerings. As of fall 2015, the center had nine external grant projects underway, cumulatively valued at approximately \$5 million. Return on investment of state general revenue funds allocated to the center is significant. Over the past four years the approximate ratios of total revenue to general revenue funds have been 4:1 for initiatives undertaken directly by the center, 3:1 for projects assisted by the center, and 12:1 for projects encouraged by the center but undertaken by parties not affiliated with the center.

Recommendations

The Academic Planning Committee makes the following recommendations to be addressed within the next regularly scheduled review cycle. In the next center review self-study, tentatively due October 1, 2019, the committee asks the center to describe actions taken and results achieved for each recommendation.

- The committee concurs with the center goal of increasing adoption of the *Creative Core Curriculum* by school districts nationwide and of training teachers and administrators in those districts how to implement the curriculum. Achieving this goal will help improve teaching in STEM disciplines, which, in turn, will help better prepare students for STEM studies at the postsecondary level and ultimately for careers in STEM fields. Increasing adoption of the curriculum will also help the center diversify its revenue streams, which, in turn, will help the center continue its work.

- The center has a long history of involvement in projects intended to assist youth from underrepresented groups in attaining excellence in STEM fields. One example is the Urban STEM-Ed initiative. The committee encourages the center to expand such efforts by involving students from underrepresented groups in center initiatives and to develop new initiatives that focus on serving that population.
- The committee concurs with the recommendation made by the center to explore extending work of the center from its emphasis on K-12 STEM education to supporting undergraduate STEM education at Illinois State University and at other institutions of higher learning. One aspect of this effort might involve exploring ways to improve student learning outcomes in STEM disciplines. The center might also explore ways to involve more undergraduate students in research sponsored by the center.
- While the committee appreciates concerns articulated in the self-study report regarding costs involved in supporting a center advisory board or council, the committee encourages center leadership to reconsider its decision not to establish such an entity. Advisory boards are used by programs and centers across the University to help establish priorities and to guide successful implementation of programs and initiatives. Advisory board members can help disseminate information about the center and its work throughout the state and beyond. Advisory board members can also help centers identify and pursue external funding opportunities. To minimize financial outlays associated with operating an advisory board, the center might consider limiting the number of board meetings each year and holding some meetings virtually using teleconferencing or videoconferencing technologies.