

Center for Mathematical Modeling Evaluation

Introduction

The external committee was asked to review the progress and achievements of the Center for Mathematical Modeling (CMM). The members of the review committee met on Monday, September 8, 2008 to review the reports, evaluations, and other documents provided by CONICYT. On Tuesday and Wednesday, September 9 and 10, 2008, the committee visited the Center and met with various groups, including the Director, program leaders (including the group at Concepcion), associated researchers, postdocs, students, administrative staff, and laboratory scientists. The CMM has been in operation for eight years. In this report we assess the current status of the Center in the areas of research, education, knowledge transfer, collaboration, and outreach. We evaluate the Center progress and achievements and make some recommendations about various aspects of the Center.

Executive Summary

The CMM is a unique institution in Chile and one of the very few successful international centers in applied mathematics. It broadly spans the mathematical sciences from basic research to highly practical applications where mathematics can make significant contributions. The outstanding strength of the research conducted is attested to by the number of publications in very high quality refereed journals. The industrial projects are very much relevant to the Chilean economy and the contributions of CMM staff to these projects are highly significant. The education component involving students and postdocs goes hand in hand with the research activities. At the same, the CMM is deeply involved in educating the next generation through its interactions with the Ministry of Education, in preparing high school mathematics teachers and its efforts in developing new curricular materials. The CMM continues to expand its international connections through joint research collaborations, and international conference held in Chile. The new BASAL grant promises to move the CMM to an even higher level of achievement and accomplishment by increasing substantially the number of faculty, students, and projects. In summary, the CMM continues to make impressive progress in all areas of its mission and this review committee strongly recommends continued support by CONICYT.

I. Center progress and achievements

The faculty of the CMM comprises 23 researchers from the University of Chile and 6 from the University of Concepcion. In addition, there are 4 external associate researchers, 17 project engineers, and 7 scientists. These groups are very productive, measured in terms of number and quality of publications and in terms of developing and implementing joint applied projects with industry, government ministries, and other non-academic entities. We were particularly impressed with the laboratory projects we saw in biomining, fracture development in mining, copper harvesting by injection of sulfuric

acid, and environmental modeling. We found the presentations by the group leaders, ranging from fundamental mathematics to applied problems, to be of high quality by international standards. Articles published by members of the Center appear in high quality international journals. What is unique in the case of CMM is the very strong connection between theoretical research and its applications to real world problems. There are only very few examples in the world where these two components are integrated so successfully.

Members of the Center have embarked on a number of projects in education aimed at improving the teaching of mathematics at primary and secondary schools in Chile. They have conducted successful summer schools for teachers, have designed a videogame to attract young students to mathematics, are producing new textbooks, monographs, and case studies for classroom use, and are running regular seminars on cognition and learning as well as more general issues in mathematics education.

Nearly all CMM faculty members have been involved in applied projects. Much of this work has appeared in the public domain in the form of refereed publications or technical reports. Although some of the work was developed under confidentiality agreements, it was still possible to publish much of it without compromising the proprietary nature of the work; this is consistent with international practices in academic institutions elsewhere in the world. We believe that the ideas and methods developed in these publications will have significant impact in future applied research. Although we did not have the opportunity to meet with industrial partners, the fact that these partners continue to fund these projects and initiate new ones makes it evident that these interactions between the CMM researchers and their project partners are proceeding successfully.

International networking in the mathematical sciences is extremely important, especially for a country like Chile which is geographically remote from most of the active centers in the world. We are impressed by the successful efforts made by CMM to develop communication networks with several outstanding centers including CNRS, PIMS, MITACS, and MATHEON. This intercommunication brings regular postdoctoral exchange with CNRS, visiting CNRS faculty, regular visitors from other countries to CMM as well as visits by CMM faculty and students to other mathematical groups around the world. These interactions have resulted in joint papers of CMM researchers with international collaborators. The CMM has also sponsored and co-sponsored a large number of Congresses and workshops which have helped to initiate new international interactions.

The outreach efforts of the Center have been so far largely focused on educational activities and working with local museums. We understand that the CMM is planning to sponsor a series of public lectures in order to increase the public awareness of mathematics.

II. Value added by the Center

There is certainly much added value contributed by the Center. How is this manifested? The existence of the CMM provides a strong framework for interaction between applied mathematicians and industry. It is rather rare to see faculty, postdocs, graduate students and undergraduates all working together on the same project. Such a vertically integrated approach provides a great experience for the students and prepares them for a successful career. The CMM facilitates the initiation and development of projects for faculty who otherwise would find it difficult to make connections on their own. The CMM provides a unique resource for industry in Chile to seek assistance in mathematical modeling for solving problems they face. The Center continues to develop new connections with other sectors of the Chilean economy. One important example is the financial sector, including banks, insurance companies, and other key institutions. They have also recently started a project with the wine industry, another important part of the nation's economy. A different line of activity is the linkage with primary and secondary education, which continues to increase. The expertise of the CMM members involved in education continues to provide a unique perspective for enhancing the mathematics curriculum.

III. Management

The management of the CMM consists of a Director and the six members of the CMM Academic Committee. This committee meets weekly to discuss all aspects of the Center's operations, including new projects, current and proposed policies, and new hires. The decisions made at these meetings are posted on the CMM Intranet and made available to all associate researchers. To the best of our knowledge, until recently, the Academic Committee was appointed by the Director. We were told that, in the future, 2/3 of the members of the committee will be elected by the Center members, with the remainder to be appointed by the Director of CMM. There is also an International Scientific Committee which we discuss later in this report. We also met the administrative staff of the Center, including the secretary, journalist, financial and human resources staff and the informational technology (IT) staff.

Overall, we believe that this management design is appropriate in structure for a center of this size and scope and that it operates effectively. The staff members provide essential services for the success of the Center and they do so extremely well. They have strong loyalty to the CMM and all work hard to meet the goals of the Center. We can illustrate the effectiveness of the staff by just one example: whenever we requested new documents or information during our visit, they were very quickly prepared and made available to us.

We would like to suggest that the CMM begin to develop an integrated database that could include such information as: (1) data on participants, including visitors, conference attendees, students and postdocs, (2) program activities, (3) financial information, (4) current and former projects, (5) educational activities, (6) conferences and workshops, (7) applications for faculty and postdoctoral positions, and (8) tracking students and postdocs after they have left the Center. Such a database would be extremely useful to the management of the Center, especially as the CMM moves to the next phase of activities under the new BASAL grant.

IV. Recruitment

Based on the information we received, we believe that the overall quality of the faculty, postdocs, and students recruited by the CMM is high. The CMM has hired strong faculty whose interests are consistent with the mission of the Center and who contribute greatly to its goals. The undergraduates represent some of the most talented mathematics students in Chile. Those interested in graduate study are encouraged to study abroad in order to broaden their perspectives and develop international collaborations. Many of them return to Chile after receiving their doctorates. Perhaps because of this, most of the graduate students in the CMM program come from abroad; nevertheless some of them stay on. Many of the graduate students from other countries learned about the CMM through the connections their professors had with CMM faculty or programs. The CMM postdocs come mostly from abroad, are highly qualified, have developed strong collaborations with existing faculty, and a significant number of them remain in Chile after completing their postdoc.

The CMM is facing a big challenge as a result of the new BASAL grant, namely, the recruitment of ten new faculty members within the next five years; they also expect to increase the size of their graduate program by 50%. This is in addition to the ongoing annual recruitment of new graduate students and postdocs. In order to successfully address this new challenge they will need to rely more heavily on their international advisory committee and on colleagues in the various networks they have developed.

V. Mentoring

Each graduate student has a CMM mentor; some students have a second mentor either from CMM or abroad. This system seems to be working effectively. A few of the students are involved in projects. On the whole, the students are very pleased with the educational experience at the CMM. Nevertheless, we think that in order to broaden the education of the students, both undergraduate and graduate, the following new activities should be initiated:

1. A course in mathematical modeling for advanced undergraduate or beginning graduate students focused on case studies;
2. A weekly industrial problems seminar, in which “real” problems from industry will be presented either by an industrial researcher or by a faculty member working with industry; and
3. A meeting or series of meetings early in each academic year, where CMM research groups present an overview of the research interests of their members to the students

VI. Institutional Commitments

The facilities of CMM are superb and this demonstrates the strong commitment of the administration to the Center. We were told that the administration has made a commitment for additional space as a result of the awarding of the BASAL grant and the expected expansion of the faculty and students associated with the Center. This contribution by the administration is essential. A quick examination of the CMM budget shows that the partner institutions, including the University of Chile, industrial partners, CNRS, and others, represent the largest share of the financial resources of CMM. This is another strong commitment by CMM partner institutions. The ongoing existence and growth of such partner contributions are essential to the future of the Center.

VII. Advisory Committee

The International Scientific Committee currently consists of ten distinguished mathematical scientists from North America, South America, and Europe. This committee reviews CMM activities and provides scientific directions to the Center. Each member typically visits the Center once each year and, upon occasion, several of these members came at the same time. There have also been a number of videoconferences. We were told that several members of this committee were extremely helpful during the development of the BASAL proposal.

We believe that, in addition, the entire committee should have a face-to-face meeting once a year at the CMM. We also believe that the members of this committee should be appointed for limited terms, and that the resulting rotation of membership should be done in a way that preserves continuity and ensures breadth of perspectives.

VIII. Other Comments

1. Concepcion: We were impressed by the presentation of Professor Gatica from the University of Concepcion. This is a coherent group working in numerical analysis, which is complementary to the work done by their colleagues in Santiago. At present, there do not appear to be strong research collaborations between the groups in Concepcion and Santiago. However, the Concepcion group is very active and publishes regularly in high quality journals. We think it would be useful for the two groups to get together to discuss ways and means by which they could strengthen their interactions.
2. Industrial Advisory Committee: The Center has made remarkable progress in its interactions with industry and government projects. It is now the appropriate time to set up an industrial advisory committee. (This was also suggested by recent reviewers.) We see the role for this committee as helping to increase the number of projects and the number of companies affiliated with the CMM, as the Center is expanding its scope. We were pleased to learn that a new business manager has been hired to promote interaction with industry and to develop the industrial advisory committee.

3. Jaime San Martín was recently appointed as Director of the CMM. The research activities of Professor San Martín have been interdisciplinary in scope. They ranged from stochastic differential equations to dynamical systems and included diverse applications in linear programming, theoretical biology, stochastic processes, and diffusion equations. He previously served as the chair of the Department of Mathematical Engineering (DIM). This background and experience make him highly qualified to lead the Center and provide the scientific vision it requires. He is well prepared to lead the CMM through the next stage of its evolution as it grows in size and scope.

Santiago, September 11, 2008

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