美国大学生数学国际合作研究

Research Experiences for U.S. Undergraduate Students in Hong Kong

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编者按：本文作者应编者的邀请，把他们组织的美国大学生海外研究体验形成文字，供中国两岸三地的大学生和基金委参考。我们非常感谢，这两位美国学者如此认真地提供了一份内容丰富图文并茂的报告。本文不仅对培养大学生研究兴趣的教师或学术基金单位有启发，也为我们写相关的结题汇报提供了一个高质量的范文。

1. 引言

2006年，位于美国科罗拉多州的科罗拉多矿业学院（Colorado School of Mines）数学与计算机系在美国国家科学基金委的资助下启动了一个为期三年的大学生研究体验（Research Experiences for Undergraduates，以下简称REU）项目。美国国家科学基金委是美国政府支持下的一个重要的基金机构，用于资助自然科学和工程方面的研究；而其支持的 REU项目旨在支持在校大学生参与有实际应用的研究活动。数学与计算机系受资助的REU项目被称为 “美国-香港数值分析与科学计算”，此项目分别于2006年至2008年的夏季以香港浸会大学为中心在香港举行。在香港设立REU项目的目的是为学数学的大学生提供一个参与具有国际水平数值分析和科学计算研究的机会，并拓宽他们的全球视野。在每届活动中，十名学生以分组的形式用八周的时间研究一些开创性的课题，每个小组由二至三名大学生组成，他们均是从美国各地的大学申请人中经过严格评审后选拔出来的。每个小组配备一名指导教师，这些教师来自包括香港浸会大学、香港城市大学、香港中文大学和香港理工大学在内的四所大学。

本文主要介绍美国基金委的REU项目，重点是香港站REU项目的独特之处。需要声明的是，本文的工作得到国家科学基金委的部分资助。另外，本文的观点和思想仅代表作者本人，并不一定代表基金委的观点。

1. Introduction

In 2006, the Department of Mathematical and Computer Sciences (MCS) at the Colorado School of Mines (CSM), located in Golden, Colorado, U.S.A., established a three-year Research Experiences for Undergraduates (REU) program funded by the National Science Foundation (NSF). The NSF is a major funding agency in science and engineering supported by the U.S. government. NSF REU programs are designed to support the active involvement of college students in meaningful research activities during their undergraduate education. The MCS REU program, entitled "United States-Hong Kong REU in Numerical Analysis and Scientific Computing", was held during the summers of 2006, 2007 and 2008, and was centered at Hong Kong Baptist University (HKBU). The purpose of establishing an REU program in Hong Kong was to provide undergraduate mathematics students with the opportunity to contribute to the exciting research being conducted in numerical analysis and scientific computing at an international level while also affording these students the chance to increase their global awareness. During each summer of the program, ten U.S. undergraduates spent eight weeks working on original research projects in teams comprising two or three student members supervised by a faculty member from one of four Hong Kong universities: HKBU, City University of Hong Kong, The Chinese University of Hong Kong and Hong Kong Polytechnic University. The student participants were selected from a broad spectrum of colleges and universities across the U.S. through a rigorous application and review process.

This article describes the NSF and its REU programs, the participating U.S. institution (CSM) and its prior REU efforts, and the unique Hong Kong REU program. It expands significantly upon [4] and [5] which focused only on the first year of this program; two additional years have since been completed. This work was partially funded by the NSF (grant DMS-0453600). The opinions and ideas expressed in this article are those of the authors and do not necessarily reflect those of the NSF.

2. 美国国家科学基金委和REU项目

1950年，美国国家科学基金委作为一个独立的美国联邦机构由美国国会批准建立，其目的是“推动科学的进步，推进国家的健康、繁荣和富裕，加强国防等等”。这一使命是通过提供科研资金给前沿课题研究人员来实现的，而选择资助的项目要通过严格的竞争筛选过程。它包括7个分部门：生物科学，计算机信息科学与工程，工程，地球科学，数学和物理科学，社会、行为和经济学，教育与人类资源，每一个部门又被细分为几个部分。其2009年的预算大致是65亿美元，其中约20%的基础研究是通过美国国家科学基金委的资助在大学和学院里完成的（参看：http://www.nsf.gov/about）。

美国国家科学基金委使命的一个重要组成部分就是对所有层次的科学和工程教育给予支持——从幼儿园到大学教育。REU项目就是其中一个大学生层次的例子。基金委推出REU项目是基于这样的理论：让学生较早地参与研究可以使他们更倾向于追求科学和工程领域（包括教学和相关的教育研究）的相关事业。

基金委资助两类REU体验：REU补加资助和REU站。 REU补加资助是拨款给受基金委资助的个人和团体，用来支持他们吸纳本科学生参加到基金委资助的项目中。如果其内容与其研究课题有关联，项目负责人可以直接向基金委申请REU补加基金，项目负责人也可以把REU作为新的研究计划的一部分向基金委申请。另一方面，REU站则不要求申请人有在研的基金项目，但需要呈交独立的计划去说明如何启动和发展让大学生参加研究项目。通常情况下，补加基金在学年和暑期都可以使用，而REU站基金则只支持暑期的项目。

3. 早年科罗拉多矿业学院的REU站基金

矿业学院于1874年在美国科罗拉多州金色市创立，为的是服务于科罗拉多的采矿社区。当1876年科罗拉多成为一个州的时候，矿业学院就成为一个州立学院。今天它是一个专门致力于自然资源、环境和相关领域的公立研究型大学。它是美国工程和应用科学方面最大的专业大学之一，大约有4000名学生，其中有800名研究

2. NSF and REU Programs

In 1950, the NSF was established by the U.S. Congress as an independent federal agency, “to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…" [8]. This mission is fulfilled through the funding of limited term grants which are selected var a highly competitive merit review process. NSF comprises seven directorates: Biological Sciences, Computer and Information Science and Engineering, Engineering, Geosciences, Mathematics and Physical Sciences, Social, Behavioral and Economic Sciences, and Education and Human Resources, each of which is subdivided into divisions. NSF’s 2009 budget was approximately US$6.5 billion (see: www.nsf.gov/about/congress/111/highlights/cu09_0310.jsp). Around 20% of the basic research completed in U.S. colleges and universities is funded through the NSF (see: www.nsf.gov/about/).

A major component of NSF’s mission is the support of science and engineering education at all levels, pre-kindergarten through graduate education [8]; the REU program is one example at the university undergraduate level. The

美国国家科学基金委大楼

National Science Foundation Building

theory that supports the NSF/REU program is that early exposure to research will entice more students to complete advanced degrees, and pursue careers in science and engineering including teaching and related educational research. NSF funds two types of REU experiences [9]: REU supplements and REU sites. REU supplements are awarded to individual investigators or investigative teams to support the inclusion of undergraduate students in research being conducted as part of NSF funded programs. Investigators can request an REU supplement through a proposal which is directly linked to an existing NSF research grant or included as a component in a proposal for a new NSF research grant. NSF/REU site grants do not require that the applicant have a currently funded NSF project but are based on independent proposals to initiate and conduct projects that engage undergraduate students in research. Supplements typically provide financial support to students during either the academic year or the summer, whereas site grants only fund summer programs.

生。矿业学院在科罗拉多州中有着最高的招生标准，并且也是全美公立大学中招生标准最高的学校之一。

除了充满生机的研究生项目外，矿业学院的数学与计算机系还通过REU补加基金拨给在研项目和现有的国家科学基金站，为大学生提供提前研究的机会。这一基金站在前系主任Graeme Fairweather博士的指导下在矿业学院的校园内举办了2000年至2002年的暑期项目。这三届活动中，共有28名学生参加，其中2000年有9名，2001年有10名，2002年有9名，一共有13名女生，15名男生，他们是从175名申请者中选拔出来的。在历届项目的六周时间里，这些参与的学生2-3名结为一组，与数学与计算机系的一名教师或博士后一起做很有开创性的研究工作。

作为评估环节的一部分，REU学生在结束暑期项目之前，需要完成一个书面调查报告和面谈，调查报告包括17个莱克特量级问题，这些问题是关于刚刚参加的REU经历会怎样影响他们对数学研究的兴趣。学生们需要给17个问题打分（0-10级），分数越高就表明对这个问题越肯定。评估还包括一些自由回答的问题，比如“在科罗拉多矿业学院参加REU项目如何影响你的受教育和职业目标？”大多数的学生表示这个项目增加了他们对研究生学习的兴趣，而且更确信从事数学科学的职业适合他们。收集来的数据再度表明REU的学生一般会计划通过进入研究生院来继续他们的学习。事实上，10名女生和7名男生在参加完项目后就立即开始攻读研究生学位了。

4. 促成REU香港设站

2000年，基金委国际项目部开始鼓励美国的研究者建立国际REU站。一段摘自基金委的项目通告写道：“美国科学和工程研究队伍需要迎接全新的和不同技能的竞争。……最好的技术训练一定要懂得怎样将专业技术知识与社会大环境、本国国情、以及其它国家的目标相结合。”与这些目标相呼应，美国大学协会在《在全球化经济中取得成功，大学如何为学生做好准备》（见[6]）一文中将下面几条作为不可缺少的要素，它们对当今的大学毕业生来说也是至关重要的：i)需有不同小组之间分工合作的团队技能，ii)全局观念和发展观，

3. Prior NSF/REU Site Grant at CSM

CSM was established in Golden, Colorado, U.S., in 1874 to serve the mining community of Colorado. When Colorado became a state in 1876, CSM became a state institution. Today, it is a public research university with a special focus on natural resources, the environment, and related fields. It is one of the largest colleges of engineering and applied sciences in the U.S., serving a student population of approximately 4000 students including 800 graduate students. CSM has the highest admission standards of any university in the state of Colorado and has among the highest admission standards of public universities throughout the U.S. [2].

科罗拉多矿业学院校园

The Campus of Colorado School of Mines.

In addition to a vibrant program in graduate research, MCS had offered several prior opportunities for research experiences for undergraduates through REU supplements to existing NSF grants as well as an NSF site grant (DMS-9912293) in the mathematical sciences which was implemented on the CSM campus during the summers of 2000, 2001 and 2002, under the direction of Dr. Graeme Fairweather, former department head of MCS. Over the course of this three year program, there were a total of 28 student participants, nine in 2000, ten in 2001, nine in 2002, with 13 females and 15 males, selected from approximately 175 applicants. For six weeks during each summer of the program, the participating students worked in teams of two or three with an MCS faculty member on an original research project. The following refereed journal articles were produced as a result of this research; an asterisk (*) denotes an REU student author.

•B. Bialecki, G. Fairweather, D. B. Knudson, D. A. Lipman*, Q. N. Nguyen, W. Sun and G. M. Weinberg*, “Matrix decomposition algorithms for the finite element Galerkin method with piecewise Hermite cubics”, Numer. Alg., 52 (2009), pp. 1-23.

以及他们对未来将产生的影响。这些论点反映了美国一个日益增长的忧虑，那就是没有足够的学生特别是研究生层次的学生准备参与自然科学和工程的研发工作，也没有充足的学生准备参与全球经济竞争。在基金委的项目通告中重申“东亚呈现出培养科学和工程人员的鲜明挑战。东亚是对美国具有重要战略意义的地区，该地区拥有具有科学天赋的精英骨干、迅速发展的技术源泉以及为美国技术产品提供崭新市场的潜力”。在回复基金委的项目通告中，当时数学与计算机系的两位教师Fairweather博士和王军平博士提交了申请并且获得了REU补加形式的基金，这是对原来REU站基金的一个补充，用以支持他们去香港一周调查设立REU国际站的可行性。在香港期间，这两位学者会见了来自香港四所大学的代表。会谈的一个结果就是设立本文所说的新的REU项目的构想。随后由这两位博士和本文的第一作者起草的申请成功地获得了国家基金委的资助。

香港被选作可行的REU站有以下几点原因。第一，它集中了一些数值分析和科学计算方向有实力的大学；第二，Fairweather和王博士最近与香港地区进行数值分析与科学计算研究的大学进行了交流，感觉和这些教师们的合作很放松很愉快；第三，英语是香港的官方语言，这极大程度上降低了潜在的语言障碍；第四，香港被认为是有极小健康风险的地区。根据美国疾病控制和预防中心的说法，去香港的访客也要“遵循类似的健康预备措施，就象在美国旅行一样”；第五，香港被很多人视为中西方文化的融合体；最后一点，香港是亚洲最安全的城市之一。

5. 香港REU体检

这一国际REU项目的目标是：提高大学生追求数学科学方面高等学位的兴趣；以及为参加的学生们提供在数学科学方面体验高质量国际研究的机会。

这一节我们将讲述REU参加者和活动，以及相关目标是如何实现的。

参加者

每年，我们会从大约50名申请者中选出10名，根据他们在数学学科上的学习表现、职业兴趣和目标，还

•K. Bold*, C. Chen* and N. Dutzman*, “An introduction to the computation of American options”, University of Texas Undergraduate Research Journal, 1 (2002), pp. 38-43.

•W. Navidi and E. Weinhandl*, “Risk set sampling for case-crossover designs”, Epidemiology 13 (2002), pp. 100-105.

As part of the evaluation process, the students completed a written survey and an exit interview at the conclusion of the REU experience. The survey included seventeen Likert scale type questions in which the students rated the extent to which project participation had impacted their interest in research in the mathematical sciences. The evaluation also included free response questions, such as "How has participating in the REU program at the Colorado School of Mines influenced your educational and career goals?" The majority of students indicated that the program had increased their interest in graduate studies and reassured them that a career in the mathematical sciences was appropriate for them. The collected data additionally indicated that the REU students generally planned to further their education by continuing into graduate school. In fact, ten females and seven males pursued a graduate degree immediately after participating in the program.

4. Impetus for Hong Kong REU Site

In 2000, NSF’s Division of International Programs began an effort to encourage U.S. researchers to establish international REU sites. A key excerpt from the NSF program announcement states: "The U.S. science and engineering (S&E) workforce is competing in a context that demands new and different skills and competencies…The best technical training must be combined with an understanding of how that expertise fits into the larger societal environment, into our overriding national goals, and into the goals of other nations.” Consistent with these goals, the Association of American Colleges And Universities [6] identified the following learning outcomes as critical areas of need for recent college graduates: i) teamwork skills and the ability to collaborate with others in diverse group settings, and ii) global issues and developments and their implications for the future. These arguments reflect a growing concern in the U.S. that there are not enough students prepared in science and mathematics and there are not enough students prepared to participate in a global economy, especially at the graduate level [3, 7]. In the NSF program announcement, it was further argued, “East Asia presents clear challenges and opportunities for developing an S&E workforce. It is a region of strategic importance to the United States, with a strong cadre of scientific talent, a rapidly developing technological base, and the potential to provide significant new markets for U.S. technological products…” In response to NSF’s program announcement, Dr. Fairweather and Dr. Junping Wang, both MCS faculty members at that time, submitted a proposal and received funds in the form of a supplement to the original REU site grant to support a visit to Hong Kong and investigate the feasibility of establishing an REU site (DMS-0206884). This visit led to the creation of the REU program described in this article (DMS-0453600).

Hong Kong was selected as a potential REU site for several reasons. First, its concentration of universities with excellence in numerical analysis and scientific computing is exceptionally strong. Second, Drs. Fairweather and Wang had previously interacted with numerical analysis and scientific computing university

有他们是否乐意参与这一海外项目。大多数参加者是从基金委网站上了解到此项目的，还有一些则是通过系里的教师了解到相关信息。这些教师能定期收到美国数学协会的电子通知，并且大都在参与美国应用和计算数学方面的研究项目。在总共三次活动的三十名学生参加者中，除去其中5名外都在一年内完成本科学业并且都声明主修数学。

基金委鼓励参与者来自a)科学和数学界的弱势群体（类似于中国的少数民族）；b)研究机会受限制的学术单位；c)非主办单位。每年此项目招收5名女生5名男生；总共三次活动的三十名参加者中两名是西班牙人或葡萄牙人；他们来自于24间大学，其中只有5间为博士学位授予单位；30名学生中，只有5名来自于科罗拉多矿业学院。在美国的数学界，女性和西班牙或葡萄牙裔学生被分类为弱势群体。虽然大多数参加者都有过研究经历，但是这次却是他们第一次有海外旅行的机会。

国际旅行和研究的准备

在前往香港之前，学生们会被分配到研究小组中，小组是由香港的一间大学的教师和两至三名学生组成。随后很快他们之间就建立起电子邮件往来。此外，这些学生还会拿到一些有关课题和实际问题的资料，后者包括当地文化的知识、旅行安排、保险事务、食宿、健康和安全等方面。除此之外，他们还要完成一份评估问卷，这在第六节将会提到。

每次暑期活动中，在五月的最后一周，学生们会在香港旅游。国家基金委指定的首席调查员Fairweather博士陪同学生们一起，住在香港浸会大学的吴多泰国际中心宾馆。这个校内住宿安排为REU的学生们提供了一个愉悦的环境，购物、就餐和交通都很方便。主办单位还为学生小组提供了办公空间以及享用图书馆和计算设施的便利，最重要的当然是提供了做为研究顾问的优质教师。

研究计划

参加项目的香港老师们在活动期间担任14项研究课题；这些课题和研究团队以及他们所属的单位都列在附录中。原本希望所有的学员在常微分方程，线性代数，数值方法，编程语言例如C，Fortran或者Matlab方面有

faculty from this region, providing ease in communication and comfort among the faculty participants. Third, English is the official language in Hong Kong, minimizing the potential of language barriers. Fourth, Hong Kong is recognized as a country that provides minimal health risks. According to the U.S. Center for Disease Control and Prevention, visitors to Hong Kong should “observe health precautions similar to those that would apply while traveling in the United States”. Finally, Hong Kong is one of the safest cities in Asia.

5. Hong Kong REU Experience

The project goals for this international REU program were:

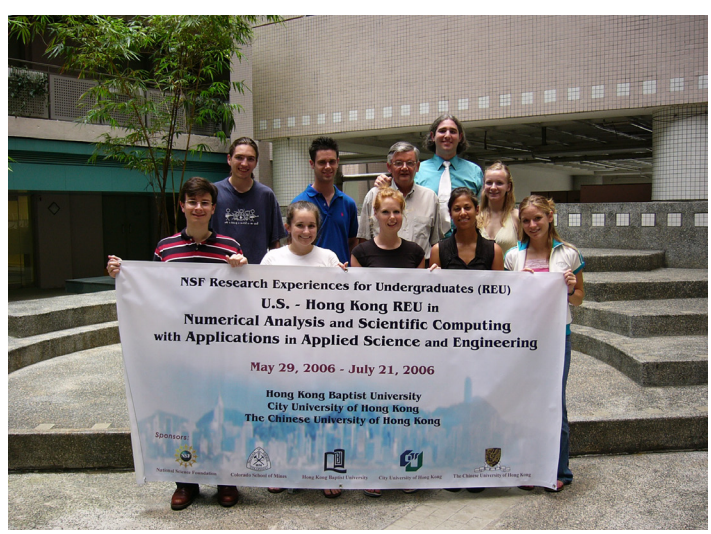
•to increase undergraduate students’ interests in pursuing advanced degrees in mathematical sciences; and

•to provide participating students with a high quality international research experience in the mathematical sciences.

This section describes the REU participants, and the activities that were designed to support the attainment of these goals.

Participants

Each year, ten participants were selected from a pool of approximately fifty applicants, based on their academic performance in the mathematical sciences, career interests and objectives, and readiness to pursue an overseas project. Most of the participants learned of the program from the NSF webpage listing all such programs [11]. Others learned of it from faculty members who received electronic



REU 香港站的第一批学生.

REU 2006 students in Hong Kong

fliers sent through list servers of the Mathematical Association of America and other leading U.S. programs in applied and computational mathematics. All but five of the 30 student participants were within one year of completing an

很强的基础。但是这并不现实，因为在美国的大学教育环境下，一些重要的专业课程通常是在最后一个学年修完的。考虑到这一点，我们要非常谨慎地保证每个小组能聚集起来指定课题所需要的各种技能。这些学生很有天赋，并能很快激发起处理知识不足的积极性，这主要是通过他们之间的相互合作达到的。

在活动期间，学生小组会向Fairweather博士以及其它学生做几次口头的进展报告。这些中期报告包括讨论他们取得的成果的讨论，遇到的问题和解决方法，以及接下来的课题目标。在活动要结束的时候，每个小组要准备一个最终的书面报告并给出一个30分钟的演讲。听取最终报告的包括做研究顾问的教师和来自香港浸会大学的师生。

Fairweather博士在整个活动中自始至终作为一个直接的全权顾问和领导，当学生们遇到课题有关的困难时，会直接帮助他们。学生们还可以以小组或者个人的形式约见他并和他讨论不同的问题，诸如研究生学习以至职业选择。

研究之余的活动

每年，REU的学生都有机会参加一些既定安排之外的活动，为的是让他们置身于更广阔的国际数学研究的视野之下。例如，许多REU学生参加博士生的答辩和听取访问学者的报告。他们还有机会参与学术会议，包括在2006年六月由香港浸会大学主办的第二届结构矩阵国际研讨会；2008年六月由香港城市大学主办的应用数学的模型分析和计算方法国际会议，以及同年在香港举办的国际计算数学基础研究系列会议的香港站会议。有两名2007年的学生参加了在香港举办的亚太区教育的职业领袖论坛。

2006年的REU学生还有机会与来自斯坦福大学的享有盛誉的Gene Golub院士进行非正式的讨论。随后Golub院士出席了在香港中文大学专门为REU学生开设的研讨班。

在2007年和2008年的活动中，澳门大学数学系金小庆教授安排REU学生到澳门大学进行为期一日的访问。在那里，他们参加了讨论会并会见了那里的研究生。当地的研究生还引领他们参观了校园和澳门市。另外，一

undergraduate degree and all had a declared major in the mathematical sciences.

The NSF encourages the participation of underrepresented groups, students from academic institutions where research opportunities are limited and students from institutions other than the host institution. Each year, the program involved five female students and five male students; two of the 30 participants were Hispanic; of the 24 colleges and universities represented by the participants, only five are Ph.D. granting institutions; and, of the 30 participants, only four were from CSM. In the mathematical sciences, both women and Hispanic students are classified as underrepresented in the U.S.A. Most of the participants had prior research experience but for many this was their first opportunity for foreign travel.

Preparation for Travel and Research

Before departing for Hong Kong, the students were assigned to research teams comprising a faculty member from a participating Hong Kong university and two or three REU recipients; these individuals immediately began electronic interaction. The students were also provided background material regarding their project and addressing practical issues, such as cross-cultural understanding, travel arrangements and insurance matters, accommodation and food, and safety and health concerns. Moreover, they were asked to complete and submit preliminary assessment activities which are described in the Assessment and Evaluation section of this article.

Over the three summers of the program, the participating students traveled to Hong Kong during the last week of May. The principal investigator of the NSF award, Dr. Fairweather, also traveled to Hong Kong, and stayed with the students in the Ng Tor Tai (NTT) International House at HKBU. This on-campus housing provided a pleasant environment for the REU participants, conveniently located for shopping, dining and transportation. The host institutions provided the student teams with office space and computing facilities

Research Projects

Fourteen research projects developed by participating Hong Kong faculty members were undertaken over the course of the program. These are listed in Appendix I together with the members of the research teams and their affiliations. It was originally expected that all of the student participants would have a strong grounding in ordinary differential equations, linear algebra, and numerical methods, together with knowledge of a programming language such as C, Fortran or Matlab. However, this proved to be rather unrealistic since a key prerequisite course, numerical methods, is often a final year course in a standard U.S. undergraduate curriculum. In view of this limitation, care was taken to ensure that each team collectively had the requisite skills for the project to which they were assigned. The students were sufficiently talented and well motivated that they quickly addressed any deficiencies in their knowledge, primarily through their interactions with other participants.

During the course of the program, the student teams presented several oral progress reports to their peers and Dr. Fairweather. These interim reports included a discussion of accomplishments, problems encountered and solutions, and the remaining project goals. At the end of the program, each team was required to prepare a final written report and give a 30 minute oral presentation.

REU 香港站的第二批07年学生
REU 2007 students in Hong Kong

年一度的乘船巡游香港是由香港中文大学计算机科学与工程系的蒙耀生教授组织的。蒙教授研究小组的学生们也参与了这些充满欢乐的游船活动。

6. 评估

评估是美国国家科学基金委对REU项目验收的重要部分。作为基金委资助项目的一部分，研究者们被要求收集和分析数据资料，目的是检查REU活动的效果。本文第一作者领导了评估的全部工作。

项目的前后文

在前往香港之前，REU的学生们被要求写一篇小短文（REU项目中称为“前文”），内容主要是他们将来对数学和数学界的贡献会是什么。结束项目回来后，他们要提交一篇小短文（REU项目中称为“后文”），主要是如何基于他们在香港的体验修改前文的。在他们的前文里，所有的学生都表明他们打算攻读数学或相关领域（也就是数学、计算机科学或物理）的研究生，并且大约半数学生对在这些科目之一取得博士学位感兴趣。绝大多数学生还表示他们有兴趣将来从事大学的数学教学和研究的工作。大多数学生的后文表明REU体验不仅没有改变他们的初衷，而且加强了这个愿望。REU的经历使得大多数学生坚信读研究生和从事数学工作更加适合他们。

每周反思

在项目的前七周，每周结束的时候，学生们要提交

Attendees at this presentation included faculty research mentors and faculty members and students from HKBU. Dr. Fairweather acted as a direct resource to the students throughout the program, assisting students when projected-related difficulties emerged. The students also met informally with him in small groups or individually to discuss various issues such as graduate studies and career options.

Activities Beyond Research

Each year, there were opportunities for the REU students to participate in activities designed to expose them to a broader scope of international mathematical research beyond what they were completing. For example, many of the REU students attended Ph.D. defenses and listened to talks given by visiting speakers. They also had the opportunity to attend and participate in research conferences, including the 2nd International Workshop on Structured Matrices at HKBU (2006), and, at City University in 2008, the International Conference on Applied Mathematics: Modeling, Analysis and Computation and the Foundations of Computational Mathematics Conference. Two of the 2007 participants attended the Asia-Pacific Professional Leaders in Education Conference held in Hong Kong in July 2007.

The 2006 REU students also had the opportunity to have tea and informal discussions with the now late Dr. Gene Golub, the renowned numerical analyst from Stanford University. As a result of this meeting, Dr. Golub later presented a seminar on the history of scientific computing at the Chinese University specifically for the REU students. During the 2007 and 2008 programs, the students made a day trip to the University of Macau arranged by Dr. X. Q. Jin of the University of Macau's Mathematics Department. There, they attended a seminar and met with graduate students, who provided a guided tour of the campus and city. An annual cruise was organized Dr. Yiu Sang Moon of the Department of Computer Science and Engineering at the Chinese University. This was attended by the REU students and graduate and undergraduate students in Dr. Moon’s research group.

6. Assessment and Evaluation

Assessment and evaluation are central components of the NSF/REU

一个书面的答复回答下面的问题：“反映过去一周的经历，解释你从文化上和数学上所学到的东西。”每年学生们的回答都是类似的。第一周和第二周大多数学生主要报告文化方面所见。在第三周，学生们所反映的更多地专注到数学和他们所研究的问题上来。到第四、第五周学生们开始对他们在研究中的进步表示满意。在第六周，学生们主要关心的是完成他们课题的时间不够。到第七周，学生们开始对他们的研究成果表示满意。在他们即将启程返家之际，学生们表达了既兴奋又遗憾的心情。

小组讨论

在项目的进行过程中，Fairweather博士领导着一个

REU学生课外时间去体验香港

The REU students found time to explore HK

由学生组成的讨论小组，目的是评估学生体验的质量，并且听取一些改进的建议。同时，作为研究顾问的教师们也组织了一个讨论小组，目的是从教师们当中获取一些有用的信息以便及时改进项目。

结题谈话

在研究计划结束的时候，每一个参加的学生要完成一次与Fairweather博士的结题谈话。谈话的目的是从学生们的体验中获得深层次的信息，以及确定参与此项目对学生未来目标的影响。

香港教师们的评估

作为评估过程的一个组成部分，香港的研究顾问们

REU 香港站的第三批08年学生

REU 2008 students in Hong Kong

experience. As part of any NSF funded project, researchers are required to collect and analyze data with the purpose of examining the effectiveness of the program. Dr. Barbara Moskal of MCS led the assessment and evaluation effort.

Pre and Post Project Essays

Prior to their leaving for Hong Kong, the REU students were asked to write an essay, referred to herein as a pre-essay, describing what they perceived would be their future contributions to mathematics and the mathematics community. Upon returning from the program, they submitted a post-essay that described how they would revise their pre-essay based on their experiences in Hong Kong. In their pre-essay, all students indicated their intention to attend graduate school in a mathematical field (i.e., mathematics, computer science or physics), and approximately half expressed interest in acquiring a Ph.D. in one of these disciplines. The majority of students also indicated that they had an interest in seeking a career that included college level instruction and/or mathematical research. The majority of the post-essays indicated that the experience had not changed their future aspirations, but rather had reinforced them. Most students felt that the REU experience confirmed that graduate school and a mathematical career were appropriate for them.

Weekly Reflections

At the end of each of the first seven weeks of the program, students submitted written responses to the following: “Reflect on the past week's experiences. Explain what you learned both mathematically and culturally." Each year, the students' responses were very similar. At the end of the first and second weeks, most students primarily reported cultural observations. Student reflections began to focus more on mathematics and on problems that the students were experiencing with their research by the end of the third week, and in weeks four and five, students began to express satisfaction with the progress of their research. During the sixth week, a major concern of the students was the lack of time to complete their projects. By the seventh week, the students began expressing satisfaction with the outcomes of their research. Students also expressed both excitement and regret at the prospect of returning home.

被要求给他们的每一个学生按下面这几项打分：对研究团队的贡献、最后提交的研究报告质量，以及未来的研究潜能。所有学生的每项评分都在中等或以上。实际上绝大多数学生的总评都是优秀。

结题调查

在每届REU活动结束的时候，那些参加的学生们要完成一个书面的调查报告，这份调查引用文献[10]即《项目主任手册：大学生国际研究经验的成功范例》中的问卷，包括大约50个问题，是专门为评价下面几个问题设计的：(1)活动的组织质量；(2) 学习环境；(3)学生学习的质量；(4)学术资源和学生资助；(5)活动的管理。每一位做研究顾问的老师也要完成一份书面的调查

REU 学生在办公室里和当地学生讨论问题
REU students communicated with local student

报告，这份调查是上述文献中供教师用的相应问卷，要回答的问题包括：i) 活动的组织质量；ii)学生的质量以及学生和老师的配合；iii)活动的管理；iv)顾问的培训。 两项调查都从参加者那里得到了积极的回应。

7. 课题成果

下面我们提供这个项目的成果来证明该项目的有效性。许多REU学生基于他们的课题做了会议报告，并且有两个会议报告获了奖。有几个学生还以期刊论文的形式发表了合作的工作。还有些学生发表了关于REU体验本身的报道。这些论文的合作者也在学术会议上做了报

Focus Groups

Dr. Fairweather led a focus group discussion with the students halfway through the program. The purpose of this focus group was to evaluate the quality of the students' experience up to that point, and to acquire suggestions for improvement. At the same juncture, a focus group was also held among the faculty research mentors. The purpose of this activity was to acquire information from the faculty members that was used for immediate project improvement.

Exit Interviews

At the conclusion of the research experience, each of the participating students completed an exit interview with Dr. Fairweather. The purpose of this interview was to acquire in-depth information concerning the student's experiences in the program and to determine how participation in the program had influenced the student's future goals.

Evaluations provided by HK Faculty

As part of the evaluation process, the faculty mentors in Hong Kong were asked to rate each of their students with respect to the following: contributions to the research team, the final submitted research project, and future research potential. All of the students were evaluated to be "Average" or above with respect to each question. In fact, the majority of students received a rating of "Excellent".

End of Program Surveys

At the conclusion of each session of the REU program, the participating students completed a written survey based on [10] and containing approximately 50 questions. This survey was specifically designed to evaluate the following: i) the organizational quality of the program, ii) the learning environment, iii) the quality of student learning; iv) resources for academic and student support; and v) the program's administration. Each faculty advisor also completed a written survey based on [10] in which they responded to questions concerning: i) the organizational quality and overall experience, ii) the quality of student participants and the student-adviser match; iii) program administration; and iv) adviser orientation. Both instruments resulted in positive responses from the participating groups.

7. Project Outcomes

Evidence to support the effectiveness of this program is also provided through the project outcomes. Many of the REU students gave conference presentations based on their projects, and two received awards for these presentations. Several of the students also published their collaborative work as journal articles. Still others wrote and published accounts of the REU experience itself. The co-authors of the current article also presented conference papers and published articles concerning this experience. This section summarizes these outcomes.

Conference Presentations and Awards

In total, eight conference presentations which included the participation

告并发表了涉及REU体验的论文。本节简要总结一下这些成果。

学生的会议报告和奖项

11名REU学生参与完成了8个会议报告，并获得了两个奖项。详细情况如下（其中括号中的内容表示学生参加REU的年份）：

•Tyler Drombosky(2007年)在美国数学协会（英文缩写MAA）2007年加州数学节上获得优秀学生论文奖；

•Alyson Burchardt(2007年)获得2008年科罗拉多矿业学院大学生论文奖；

•Michael McCourt(2006年)等在Argonne国家实验室的第七届大学生科技和数学年会上报告研究成果，其合作者是 Nicholas Dovidio （2006年） 和 Michael Gilbert (2006年)；

•Michael McCourt(2006年)等在2007年美国工业与应用数学学会计算科学和工程大会上报告研究成果；

•Samantha Summerson(2006年)在上面的2007年大会上报告研究成果，其合作者是Meghan Belinski（2006年） 和 Andrea Martinez(2006年)；

•Sarah Khasawinah(2008年)在美国数学协会2008年年会和美国女大学生数学年会上做学术报告；

•Samantha John(2008年)在第十一届美国女大学生数学年会上做学术报告；

•Anna Meade(2008年)在美国数学协会路易安那和密西西比州第86届年会上作报告。

期刊论文

另外，8位学生独立或和其它学生合作完成了四篇高质量的学术论文，其中有两篇论文已经发表在SCI期刊上。另外，我们两个REU学生把REU香港站的经历整理成一篇通讯，发表在2006年11月的美国《工业与应用数学会通讯》上。

8. REU参加者的结项后成果

我们一直在努力追踪REU学生结束活动后所取得的

of eleven REU students were made and these resulted in two awards. These are summarized here.

•Tyler Drombosky (Participant 2007) was designated a 2007 AMS Award Winning Pi Mu Epsilon Student Speaker for his paper “Effective Condition Number” presented at the MAA MathFest 2007, San Jose, California, August 2007.

•Alyson Burchardt (Participant 2007) won the undergraduate award at the Colorado School of Mines Student Research Fair for a poster entitled “Super-Resolution Image Reconstruction”, April 2008.

•Michael McCourt (Participant 2006): “Chebyshev Collocation Methods for Resolving Spike Dynamics in the GM Reaction-Diffusion Model", Seventeenth Annual Symposium for Undergraduates in Science, Engineering and Mathematics, Argonne National Laboratory, November 2006. The paper was co-authored by Nicholas Dovidio (Participant 2006) and Michael Gilbert (Participant 2006).

•Michael McCourt (Participant 2006): “Spike Dynamics in the Gierer-Meinhardt Model using Chebyshev Collocation Methods", SIAM Conference on Computational Science and Engineering, Costa Mesa, California, February 2007. The paper was co-authored by Nicholas Dovidio and Michael Gilbert.

•Samantha Summerson (Participant 2006) presented a poster, “Wavelet Algorithms for High-Resolution Image Reconstruction", SIAM Conference on Computational Science and Engineering, Costa Mesa, California, February 2007, co-authored by Meghan Belinski (Participant 2006) and Andrea Martinez (Participant 2006).

•Sarah Khasawinah (Participant 2008): “Evaluation of Hypersingular Integrals using Numerical Methods”, Eastern Pennsylvania and Delaware Section of the MAA, Ursinus College, Collegeville, Pennsylvania, November 2008, and The Eleventh Annual Nebraska Conference for Undergraduate Women in Mathematics, Lincoln, Nebraska, January 2009.

•Samantha John (Participant 2008): “Predicting Exchange Rates using Artificial Neural Networks”, The Eleventh Annual Nebraska Conference for Undergraduate Women in Mathematics, Lincoln, Nebraska, January 2009.

•Anna Meade (Participant 2008): “HYmini Wind-Powered Charger Data Approximations”, MAA Louisiana/Mississippi Section 86th Annual Meeting, Mississippi College, Clinton, MS, March 2009.

Journal Articles

Eight students co-authored journal articles. These are listed below with * indicating an REU student author.

•M. McCourt*, N. Dovidio* and M. Gilbert*, “Spectral methods for resolving spike dynamics in the Geirer-Meinhardt model”, Communications in Computational Physics, 3 (2008), pp. 659-678.

•T. W. Drombosky*, A. L. Meyer* and L. Ling, “Applicability of the method of fundamental solutions”, Engineering Analysis with Boundary Elements, 33 (2009), pp. 637-643.

•E. Bassiri*, G. Fairweather and J. C.-F. Wong, “A finite element approach

成绩和专业成果。本节列出了REU学生所取得的成绩。虽然这些成绩未必能直接或完全归功于REU体验，但是他们的确反映了这些参加学生的质量。

•2006届的学生中，以下7名攻读了研究生：Nicholas Dovidio(斯坦福大学)， Michael Gilbert (亚利桑那大学)， Amanda Harsy(肯塔基大学)， Jonathan Maack(科罗拉多矿业学院)，Michael McCourt(康奈尔大学)，Samantha Summerson(莱斯大学)，和Chelsea Weitzel(科罗拉多矿业学院)。Jonathan Maack和Chelseas Weitzel自从完成硕士学位后就受雇于科罗拉多丹佛的航空航天公司。Nicholas Dovidio也已经完成硕士学位，现正受雇于纽约市的巴克莱投资银行。

•2007年的参加者中：Alyson Burchardt(布兰德斯大学) 和Bryan Romero(科罗拉多大学博尔德分校)正在读研究生，Tyler Drombosky(马里兰大学)， Ely Spears(布朗大学)和Christopher Phillips (德克萨斯大学)将在2009年秋季攻读研究生。

•Ashley Meyer现在正服务于和平工作队，在西非的几内亚教数学。和平工作队是约翰•肯尼迪总统于1961年创立的，目的是促进世界和平和国际间的理解。他还将继续出席在香港浸会大学举行的其它活动，而且他的肖像这三年里一直出现在浸会大学的校园海报上，用于推广浸会大学的国际化教育。

•Elizabeth Cheever(2007届)于2008年的春季学期在苏格兰爱丁堡大学学习。最近她被选拔出来参加“为美国而教”的项目，在即将毕业之际，她接受了一个在乔治亚州亚特兰大的教学职位。“为美国而教”是一个国家团队，成员包括新近毕业的杰出大学生和专家，他们愿

REU的学生和导师在香港浸会大学;后排中是Golub院士
REU students advisors and Gene Golub in HKBU

for the Brusselator model”, preprint.

Articles Concerning the REU Program

Two papers providing a student perspective of the international REU program were also published.

•N. Dovidio* and S. Summerson*, “An international REU program: a student perspective”, SIAM News, November 2006, p. 20.

•S. Summerson*, “U.S.-Hong Kong Undergraduate Research", 2006/2007 Newsletter, Department of Mathematics, The Chinese University of Hong Kong

Faculty Presentations and Publications

Six presentations and two published articles were completed by the authors of this article.

•G. Fairweather and B. Moskal, “Research Experiences for Undergraduates Program in Numerical Analysis and Scientific Computing”, Proceedings of the Conference on Promoting Undergraduate Research in Mathematics, J. Gallian, ed., American Mathematical Society, Providence, Rhode Island, 2007, pp. 207-212.

•G. Fairweather and B. Moskal, “An International Research Experiences for Undergraduates Program in Computational Mathematics: A Collaboration among Hong Kong Universities and the Colorado School of Mines”, Rocky Mountain Section of the Mathematical Association of America Newsletter, Fall 2006, pp. 15-16.

•G. Fairweather and B. Moskal, “Research Experiences for Undergraduates: Attracting the Next Generation of Talent to Mathematical Research", 2006 Korea-USA Forum for Attracting Gifted/Talented Students into Science and Engineering, Seoul, Korea, June 2006.

•G. Fairweather and B. Moskal, “An International REU in Hong Kong”, The Joint Mathematics Meetings, New Orleans, Louisiana, January 2007.

•G. Fairweather and B. Moskal, “A Research Experience for U.S. Undergraduate Students in Hong Kong”, Asia-Pacific Association for International Education Conference and Exhibition - APAIE, Waseda University, Tokyo, Japan, March 2008.

•G. Fairweather and B. Moskal, “International Research Experience for Undergraduate Mathematics Students: A Collaboration Between the U.S. and Hong Kong”, The Joint Mathematics Meetings, San Diego, California, January 2008.

•G. Fairweather and B. Moskal, “An International Research Experience for Undergraduates in Numerical Analysis and Scientific Computing”, SIAM Annual Meeting, San Diego, California, July 2008.

•G. Fairweather and B. Moskal, “Learning Mathematics through International Collaboration”, 4th QS Asia Pacific Professional Leaders in Education Conference - QS-APPLE, Yonsei University, Seoul, Korea, July 2008.

意投入两年的时间致力于城镇的公立学校教学。

•Mindy Schockling(2007届)于2009年的春季在南非开普敦大学学习了一个学期。

•Alyson Burchardt(2007届)，Elizabeth Cheever(2007届)，Tyler Drombosky(2007届)和 Bryan Romero(2007届) 被2008年国家安全局局长的暑期课程录取，这是一个具有极高竞争力的课程，专门招收数学方面优异的美国学生。

•Bryan Romero(2007届)和Tyler Drombosky(2007届)分别于2008年和2009年的春季参加了在匈牙利布达佩斯的数学课程。这个课程吸引了北美那些热衷于数学，愿意受益于匈牙利数学和乐意体验布达佩斯生活中跨文化探险的学生们。

•Ely Spears(2007届)被授予美国国防科学和工程研究奖金。这一研究奖金是美国国防部授予在科学和工程方面表现出特殊才能的美国公民和永久居民的。

•Tyler Drombosky(2007届)取得了Goldwater奖学金，这个奖学金的获得者是从全美理工科优秀的三年级和四年级的大学生中竞争产生的。

•2008年的四名参加者将在2009年秋季攻读研究生：Claire Curtis(匹兹堡大学)，Anna Meade(北卡罗来纳州立大学)，Sarah Khasiwanah(约翰霍普金斯大学)，

REU的学生被选中为浸会大学的宣传帖上
REU student with HKBU student are in campus poster

8. REU Participants' Post-Program Achievements

Continuing efforts are underway to track the professional accomplishments of the REU students beyond project participation. This section lists the known accomplishments of former REU participants. Although these accomplishments may not be directly attributed to the REU experience, they do reflect the quality of the student participants.

•Of the 2006 students, the following seven entered graduate programs at the indicated institutions: Nicholas Dovidio (Stanford University), Michael Gilbert (University of Arizona), Amanda Harsy (University of Kentucky), Jonathan Maack (Colorado School of Mines), Michael McCourt (Cornell University), Samantha Summerson (Rice University), and Chelsea Weitzel (Colorado School of Mines). Jonathan Maack and Chelseas Weitzel have since completed master's degrees and are employed by aerospace companies in Denver, Colorado. Nicholas Dovidio has also completed a master's degree and is now employed by Barclays Capital in New York City. Samantha Summerson is the fourth in this group to complete a master's degree, and is now pursuing a doctorate.

•.Of the 2007 participants: Alyson Burchardt (Brandeis University), Tyler Drombosky (University of Maryland, College Park), Christopher Phillips (Texas A & M), Bryan Romero (University of Colorado, Boulder), Mindy Schockling (Air Force Institute of Technology) and Ely Spears (Brown University) are in graduate school at the indicated institutions.

•Ashley Meyer is currently serving with the Peace Corps, teaching mathematics in Guinea, West Africa. The Peace Corps was established by President John F. Kennedy in 1961 to promote world peace and international understanding. Ashley continues to have a presence at HKBU where she appears in several posters around campus promoting various aspects of a HKBU education.

•Elizabeth Cheever (2007) spent the spring semester 2008 studying abroad at the University of Edinburgh, Scotland. In 2009, she was selected to participate in the "Teach For America" program and, soon after her graduation, she accepted a teaching position in Atlanta, Georgia. Teach For America is a national corps of outstanding recent college graduates and professionals who are willing commit two years to urban and rural public school teaching.

•Mindy Schockling (2007) spent the spring semester 2009 studying abroad at the University of Cape Town, South Africa.

•Alyson Burchardt (2007), Elizabeth Cheever (2007), Tyler Drombosky (2007) and Bryan Romero (2007) were accepted into the 2008 National Security Agency's Director's Summer Program, a highly competitive program involving exceptional U.S. students in undergraduate mathematics.

•Bryan Romero (2007) and Tyler Drombosky (2007) participated in the Budapest Semester in Mathematics Program in Budapest, Hungary, during the spring semesters of 2008 and 2009, respectively. This program attracts North American students "who are serious about mathematics, likely to benefit from the experience of mathematics Hungarian style, and who are excited about experiencing the intercultural adventure of living in Budapest".

•Ely Spears (2007) was awarded a National Defense Science and Engineering Fellowship. Such fellowships are awarded by the U.S. Department of Defense to

Timothy Penderghest(克拉克森大学)。

•Jason Pearson(2008届) 接受了在中国锦州的辽宁科技大学教英语的职位。

•Michael McCourt(2006届)，Samantha Summerson(2006届)和Sarah Khasiwanah(2008届)获得国家自然科学研究所奖学金，这个奖学金是用来资助有硕士和博士学位的在科学、技术、数学学科有杰出表现的研究生们的。

•Michael McCourt(2006届) 于2009年7月被选拔出来，参加在香港科技大学的约翰霍普金斯英才中心的教学项目，这是香港科技大学和约翰霍普金斯大学为有学术天赋的中学生而举办的联合项目。此外，他还在2008年6月协助REU项目在香港浸会大学举行。

•Cole Mcgee(2008届) 是美国数学协会2008年全国数学历史论文竞赛第二名得主。(见 www.homsigmaa.org/news08.pdf)。他在2009年8月接受了一份在科罗拉多一所中学教学的职位。

•2009年5月，Sarah Khasiwanah(2008届) 在布尔茅尔学院获得数学和英语的学士学位（最高荣誉）和数学的硕士学位；Eugene Milman (2008届) 在纽约州立大学获得了数学和生物化学的学士学位和应用数学与统计学的硕士学位。这两名学生只用了4年的时间就取得了学士和硕士学位。

需要指出的是，因为2008届的学生大多数在2008-2009学年底本科毕业了，他们取得的许多成绩现在还未收集到。

9. 细说目标

本文伊始我们讨论过，这个国际REU项目的目标是：(1)提高大学生在数学方面追求高等学位的兴趣；(2)为参加者提供一次体验高质量国际研究的机会。

在举办完第一届REU项目后，我们针对这些目标进行了评估。这些参加项目的学生们并非全部都提高了追求高等学位的兴趣。事实上，根据选拔原则，多数学生维持他们原来的打算，那就是追求研究生水平的学位并且从事数学方面的工作。正是因为对这个领域有兴趣，学生们才申请并参加了这个项目， REU项目的经历是加强而不是改变他们的职业目标。因此，在举办第二届活动的时候，我们将第一条目标修改为：为有兴趣追求数学方面高等学位的学生提供一个机会，让他们对数学研究的本性有更好的理解。

U.S. citizens and permanent residents who have demonstrated ability and special aptitude for advanced training in science and engineering.

•Tyler Drombosky (2007) received a Goldwater Fellowship, a highly competitive merit based scholarship in mathematics, science and engineering awarded through a competitive process to students across the U.S. in their junior (third) and senior (fourth) year of college.

•Four of the 2008 participants entered graduate school in fall 2009 at the indicated institutions: Claire Curtis (University of Pittsburgh), Anna Meade (North Carolina State University), Sarah Khasiwanah (Johns Hopkins University), and Timothy Penderghest (Clarkson University).

•Jason Pearson (2008) is teaching English at Liaoning University of Technology in Jinzhou, China.

•Michael McCourt (2006), Samantha Summerson (2006) and Sarah Khasiwanah (2008) received National Science Foundation Graduate Fellowships, a program that supports outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines who are pursuing research-based master's and doctoral degrees.

•Michael McCourt (2006) was selected to teach in the 2009 Johns Hopkins University Center for Talented Youth (CTY) at Hong Kong University of Science and Technology (HKUST) during July 2009, a joint program between CTY and HKUST for academically talented middle and high school students. He spent June 2008 assisting in the 2008 REU program at HKBU.

•Cole Mcgee (2008) placed second in the 2008 National History of Mathematics Paper Competition sponsored by the History of Mathematics Special Interest Group of the Mathematical Association of America for his paper “Jean le Rond D’Alembert: Mathematician, Philosopher, and Man of Letters” (posted at www.homsigmaa.org/news08.pdf). He nowholds a high school teaching position in Colorado..

•In May 2009, Sarah Khasiwanah (2008) received a bachelor’s degree in Mathematics and English (summa cum laude) and a master’s degree in Mathematics from Bryn Mawr College, and Eugene. Milman (2008) received a bachelor’s degree in Mathematics and Biochemistry and a master’s degree in Applied Mathematics and Statistics from CUNY Hunter College. Both graduated after only four years of study.

It should be noted that, since the majority of the 2008 cohort completed their undergraduate education at the end of the 2008-2009 academic year, many of their accomplishments are not yet known.

9. Refinement of Goals

As was discussed at the beginning of this article, the project goals for this international REU were: to increase undergraduate students’ interests in pursuing advanced degrees in the mathematical sciences; and to provide participating students with a high quality international research experience in the mathematical sciences.

After implementing and evaluating the first year of the REU program, these

通过我们的评估活动，再加上项目成果和项目结束后取得的一些成绩，有充分的证据表明我们基本实现了修改后的第一条目标和原来的第二条目标。

10. 结束语

最近的几则出版物强调了在海外地区大学生从事研究的重要性和好处，《大学生海外研究：挑战与回报》（见[1]）中指出“大学生从事境外研究活动的成果表明，不同的文化环境会加强学生获得跨领域知识的能力”。2007年发表的有关大学生的国家普查，见[12]，其信息是基于随机抽取的大约三十一万名大一和大四的学生的调查，这些学生来自于美国和加拿大的610所四年制大学。其研究结果表明：完成高影响的活动，例如大学期间去国外学习和研究，会推动学生在各个领域的表现，包括批判性思考、解决现实世界的问题、与他人有效合作等。那些在在境外学习过的学生回到自己的校园后，更愿意经常参加一些教育方面的有既定目标的活动。由此我们坚信这项REU项目在结束后仍对参加者起到了积极的作用。

毫无疑问，参加REU的学生在文化、专业和学术方面都受益良多。但是，作为研究顾问的香港的教师们并未从中得到显然的好处。作为一个学生导师需要大量的时间和精力，但是这些香港的教师们既没有得到财务补偿也没有从他们院系得到必要的奖励。也就是说香港教师们付出的时间纯粹是无偿的。这个因素大大缩减了这个项目的连续性，原因就是我们只能要求教师们在非常有限的时间内付出免费劳动。

作为数学科学范围的47项基金委支持的REU项目之一，香港REU项目建立之初，是当时仅有的两个国家项目之一。另一项是罗格斯大学与捷克布拉格的查理大学合作（见[14]），已经举办好几届了。REU项目为实现基金委培养多元的、具有国际竞争力的和全球参与的科技人员这一目标做出了重要的贡献。在当前获资助的数学科学方面的58个REU站中，只有罗格斯大学站有国际交流。建立更多的国际REU站遇到的主要困难是用于支持国外参加者的资助太有限。从2008年以后我们决定不再申请连续举办这项活动有以下两个方面的原因。首先，基金委奖学金的首席研究员Fairweather博士离开矿业学院并担任了《数学评论》的常务主编；第二，此项

goals were re-evaluated. The students who participated in the program did not uniformly display an increase in their interest in pursuing advanced degrees in mathematical sciences. In fact, due to the selection criteria, most of the students maintained their original intentions, i.e., to pursue a graduate level degree and a career in the mathematical sciences. Given that the students applied to the program and were selected to participate because they already had interests in this area, participation in this REU experience strengthened rather than changed their career objectives and opportunities. By the second year of the program, the first goal was replaced with: to provide students who are interested in pursuing an advanced degree in the mathematical sciences with a better understanding of the nature of mathematical research, what is required in graduate school, and mathematical careers.

Based on our assessment and evaluation activities, the project outcomes and post-program achievements, there is ample evidence to support that the revised first goal and the original second goal were achieved.

10. Concluding Remarks

As was previously discussed, the importance and benefits of undergraduate research in an overseas location have been underscored in several recent publications. According to [1], “Undergraduate research abroad can demonstrate that the cultural context of learning enhances the disciplinary knowledge gained”. Published in 2007, the National Survey of Student Engagement (NSSE) [12] was based on information collected from approximately 313,000 randomly selected first-year and senior (fourth-year) students at 610 four-year colleges and universities in the U.S. and Canada. Findings from this report indicate that completing “high impact” activities, such as study abroad and undergraduate research, during college boosts students’ performance in many areas, including critical thinking, real world problem solving, and working effectively with others. It was also found that students who studied overseas engaged more frequently in educationally purposeful activities when they returned to their home campus.

As part of the international REU experience described herein, extensive efforts have been dedicated to tracking the professional and academic outcomes of the three cohort groups, 2006, 2007 and 2008. The findings reported here are consistent with those of other researchers. There is little doubt that the participating REU students benefited culturally, academically and professionally from this program. However, for the Hong Kong research mentors, the benefits were not as obvious. Acting as a student supervisor required a significant amount of time and effort and the Hong Kong faculty did not receive financial compensation nor did they necessarily receive institutional recognition for their efforts. In other words, the Hong Kong faculty time was voluntary. This factor greatly reduced the sustainability of this program because faculty can only be asked to work for free for a limited amount of time.

Acknowledgments

Many parties contributed substantially to the success of this program. First we wish to thank both the REU students and their Hong Kong faculty research mentors for their time and effort in implementing this REU experience. The

目对香港的大学教师们有太多的要求，继续要求他们无偿抽出时间似乎是不合理的。

致谢

很多单位的大力支持促成了我们这个项目的成功。首先我们感谢REU学生和他们在香港的研究顾问。没有这些顾问老师的投入和他们所在单位（香港浸会大学、香港城市大学、香港中文大学和香港理工大学）的支持，这些活动是不可能成功的。我们还要感谢澳门大学数学系的金小庆教授和香港中文大学的蒙耀生教授。我们特别感谢来自伊利诺伊理工学院的Fred Hickernell教授，他在2002年担任香港浸会大学系主任时，对于我们成功地向基金委申请将REU项目站设在香港浸会大学给予了非常宝贵的帮助。我们还要特别致谢香港浸会大学的吴国宝教授和汤涛教授，以及数学系的全体职员特别是徐美儿女士。科罗拉多矿业学院的同事和全体教工的帮助，特别是Bernard Bialecki博士和Pam Beckman女士，为我们的成功提供了保障。最后我们还要感谢美国国家科学基金委对我们这次尝试的大力资助。

这篇文章要献给斯坦福大学的Gene Golub院士。他对这个项目非常支持，并且也是一位能在与学生交流中启发灵感的人物。他主动提出要参加这个项目，但是他的突然离世让我们失去了这次机会。他为很多的团体做了许多贡献，同时也给了很多人大力的支持和鼓励，我们会永远怀念他。

附录：研究计划

第一年：2006年5月29日—2006年7月21日

•高分辨率图像复原的小波算法

研究顾问：香港中文大学数学系陈汉夫教授

REU参加者：Meghan Belinski（马里兰洛约拉学院），Samantha Summerson（伯克利加州大学），Andrea Martinez（里吉斯大学）

•微分矩阵的谱分析及其应用

研究顾问：香港城市大学数学系孙伟伟教授

REU参加者：Amanda Harsy（泰勒大学），Chelsea Weitzel（科罗拉多矿业学院）

•数值模拟反应扩散系统中峰状形态的挑战

研究顾问：香港浸会大学数学系汤涛教授

REU参加者：Nicholas Dovidio（戴维森学院），Michael Gilbert（科罗拉多州立大学普韦布洛分校），Michael McCourt（伊利诺伊理工学院）

program would not have succeeded without the commitment of the mentors and the support provided by their institutions, HKBU, City University of Hong Kong, The Chinese University of Hong Kong, and Hong Kong Polytechnic University. We also thank Dr. X. Q. Jin of the University of Macau's Mathematics Department for arranging the visits to Macau, and Dr. Y. S. Moon and his students for organizing the cruises. We are particularly indebted to Dr. Fred Hickernell of Illinois Institute of Technology in Chicago, Illinois, who, in 2002 when chair of HKBU's Department of Mathematics, provided invaluable assistance in the development of the successful NSF proposal to center the REU program at HKBU. We are especially grateful to Dr. Michael Ng of HKBU who assumed the role of Hong Kong director of the program upon Dr. Hickernell's departure, and to Dr. Tao Tang and the staff in the Department of Mathematics at HKBU, particularly Ms. Claudia Chui, for their assistance, guidance and support throughout the program. We would be remiss if we did not acknowledge the assistance of our colleagues and staff at the Colorado School of Mines, particularly Dr. Bernard Bialecki and Ms. Pam Beckman. Finally we thank the NSF for its financial support of this endeavor (grant DMS-0453600).

This paper is dedicated to the memory of Dr. Gene Golub. Dr. Golub was very supportive of the program and a great inspiration to the REU students with whom he interacted. He offered to participate in the program but his untimely death robbed us of that opportunity. We will long remember him for his numerous contributions to the community at large as well as the strong support and encouragement that he gave so many individuals.

Appendix: Research Projects

Year 1: May 29, 2006--July 21, 2006

•Wavelet Algorithms for High-Resolution Image Reconstruction

Research Supervisor: Dr. Raymond Chan, Department of Mathematics, The Chinese University of Hong Kong

REU Participants: Meghan Belinski (Loyola College in Maryland), Samantha Summerson (University of California, Berkeley), Andrea Martinez (Regis University)

•Spectral Analysis of Differentiation Matrices and Applications

Research Supervisor: Dr. Weiwei Sun, Department of Mathematics, City University of Hong Kong

REU Participants: Amanda Harsy (Taylor University), Chelsea Weitzel (Colorado School of Mines)

•Resolving Spike Dynamics for Reaction Diffusion Systems

Research Supervisor: Dr. Tao Tang, Department of Mathematics, Hong Kong Baptist University

REU Participants: Nicholas Dovidio (Davidson College), Michael Gilbert (Colorado State University, Pueblo), Michael McCourt (Illinois Institute of Technology)

•Subspace Clustering for High Dimensional Categorical Data

Research Supervisor: Dr. Michael Ng, Department of Mathematics, Hong Kong Baptist University

REU Participants: Guangming Lang (New College of Florida), Jonathan Maack (Colorado School of Mines)

•高维分类数据的子空间聚类
研究顾问：香港浸会大学数学系吴国宝教授
REU参加者：Guangming Lang（新佛罗里达学院），
Jonathan Maack（科罗拉多矿业学院）

第二年：2007年6月1日—2007年7月25日

•一种基于插值的超分辨率图像复原方法
研究顾问：香港浸会大学数学系唐创时博士
REU参加者：Alyson Burchardt（科罗拉多矿业学院），
Elizabeth Cheever（布朗大学）

•突发性行为的数学模型
研究顾问：香港城市大学Felipe Cucker教授
REU参加者：Jeremy Sherman（新佛罗里达学院），
Ely Spears（罗斯-豪曼理工学院）

•有效的条件数
研究顾问：香港浸会大学数学系凌立云博士
REU参加者：Tyler Drombosky（杨斯顿州立大学），
Ashley Meyer（亨廷顿大学）

•径向基函数在插值和微分方程中的应用
研究顾问：香港城市大学数学系韩耀宗教授
REU参加者：Bryan Romero（科罗拉多矿业学院），
Mindy Schockling (首都大学）

•计算生物中的问题
研究顾问：香港中文大学黄泽富博士和邹军教授
REU参加者：Eileen Bassiri（贡萨格大学），
Christopher Phillips（加利福尼亚州立理工大学波莫那分校）

第三年：2008年6月2日—2008年7月25日

•默认相互作用的双隐藏马尔可夫模型
研究顾问：香港浸会大学数学系冯绍梁博士
REU参加者：Claire Curtis（北卡罗来纳大学阿什维尔分校），Thomas Jones（贡萨格大学）

•HYmini 便携式风力充电器的功率
研究顾问：香港浸会大学数学系凌利云博士
REU参加者：Anna Meade（密西西比州立大学），Jason Pearson（阿巴拉契亚州立大学）

•时间有关的偏微分方程的计算挑战
研究顾问：香港理工大学应用数学系姚家辉博士
REU参加者：Eugene Milman（纽约市立大学亨特学院），Kirstin Reinertson（得克萨斯A&M大学科帕斯克里斯蒂分校）

•用人工神经网络预测全球汇率
研究顾问：香港理工大学应用数学系李良坤博士
REU参加者：Samantha John（哥伦比亚大学），
Timothy Penderghest（克拉克森大学）

•双曲奇异积分的数值方法
研究顾问：香港城市大学数学系孙伟伟教授
REU参加者：S. Khasawinah（布尔莫尔学院），
Cole Mcgee（科罗拉多州立大学普韦布校）

Year 2: June 1, 2007-- July 25, 2007

•An Interpolation-Based Approach to Super-Resolution Image Reconstruction
Research Supervisor: Dr. C. S. Tong, Department of Mathematics, Hong Kong Baptist University
REU Participants: Alyson Burchardt (Colorado School of Mines), Elizabeth Cheever (Brown University)

•Models for Emergent Behaviour
Research Supervisor: Dr. Felipe Cucker, Department of Mathematics, City University of Hong Kong
REU Participants: Jeremy Sherman (New College of Florida), Ely Spears (Rose-Hulman Institute of Technology)

•Effective Condition Number
Research Supervisor: Dr. Leevan Ling, Department of Mathematics, Hong Kong Baptist University
REU Participants: Tyler Drombosky (Youngstown State University), Ashley Meyer (Huntington University)

•Numerical Methods for Inverse Problems
Research Supervisor: Dr. Benny Hon, Department of Mathematics, City University of Hong Kong
REU Participants: Bryan Romero (Colorado School of Mines), Mindy Schockling (Capital University)

•Problems in Computational Biology
Research Supervisors: Drs. Jeff Wong and Jun Zou, Department of Mathematics, The Chinese University of Hong Kong
REU Participants: Eileen Bassiri (Gonzaga University), Christopher Phillips (California State Polytechnic University, Pomona)

Year 3: June 2, 2008--July 25, 2008

•A Double Hidden Markov Model of Default Interaction
Research Supervisor: Dr. Siu Leung Fung, Department of Mathematics, Hong Kong Baptist University
REU Participants: Claire Curtis (University of North Carolina, Asheville), Thomas Jones (Gonzaga University)

•Efficiency of the HYmini Portable Wind Powered Charger
Research Supervisor: Dr. Leevan Ling, Department of Mathematics, Hong Kong Baptist University
REU Participants: Anna Meade (Mississippi State University), Jason Pearson (Appalachian State University)

•Computational Challenges in Time-Dependent Partial Differential Equations
Research Supervisor: Dr. Cedric Yiu, Department of Applied Mathematics, Hong Kong Polytechnic University
REU Participants: Eugene Milman (CUNY Hunter College), Kirstin Reinertson (Texas A&M University, Corpus Christi)

•Forecasting Global Exchange Rates with Artificial Neural Networks
Research Supervisor: Dr. Leong Kwan Li, Department of Applied Mathematics, Hong Kong Polytechnic University
REU Participants: Samantha John (Columbia University), Timothy Penderghest (Clarkson University)

•Numerical Approximations to Hypersingular Integrals
Research Supervisor: Dr. Weiwei Sun, Department of Mathematics, City University of Hong Kong
REU Participants: Sarah Khasawinah (Bryn Mawr College), Cole Mcgee (Colorado State University, Pueblo)

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