

A Framework on Collaboration: an Interdisciplinary Project across Multiple Colleges

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ABSTRACT

The order of complexity in carrying out collaborative research at multiple campuses poses a challenge to standard knowledge management systems. In this paper, we present a collaboration framework in which computer science students work in partnership with computer scientists, mathematicians and physicists on an emerging field of research, quantum information science. We first develop a few heuristic criteria to determine the rationale that makes project a successful one. We then demonstrate that our knowledge management systems produce publishable results and grant proposals within our framework.

Keywords: collaboration, interdisciplinary curriculum, asynchronous learning network, case study, science education, quantum information science.

1. INTRODUCTION

Collaboration plays an essential role in many jobs. In the business world, people participate in team projects and are evaluated on their processes and results. In schools, most educators and students recognize that the pursuit of knowledge and collaboration often cross traditional disciplinary boundaries. However, it is not commonly included in the standard academic curriculum structure.

Cross-listings of interdisciplinary courses among the departments of humanity and social science are commonplace and well accepted. It is folklore that the discipline of mathematics, science, and engineering is so specialized – both the depth and body of knowledge forbids the sharing of scholarly communication in common language. Quantum information science (QIS) is a new emerging field of research [3, 4] of science and technology,

combining and drawing on the disciplines of computer science, mathematics, and physical science. It is anticipated to have a major impact on security in commercial networks and transactions [2] while adding to the solution needs of the federal government [6]. The collaboration is intended to develop an innovative interdisciplinary research initiative that addresses the link among Computer Science, Mathematics, and Physical Science. Recently, with visionary leadership, the Graduate Center of the City University of New York (CUNY) sponsored two new interdisciplinary courses that are cross-listed among the departments of computer science, mathematics, and physics. Professors from different CUNY campuses were involved in teaching these two graduate courses: *Quantum Computing* and *Quantum Cryptography* at the Graduate Center. Twenty-three students from the Masters and Ph. D. programs have participated; the pool of students consists of computer science, electrical engineering, mathematics, and physics.

There are four components to our overall objective of the interdisciplinary project, which are as follows: to bring faculty expertise among the different disciplines from CUNY campuses; to involve students in the forefront of quantum information science; to enhance the collaborative education between community and senior colleges; and to use our knowledge management systems to produce publishable results and grant proposals. We adopt the conceptual asynchronous learning network model (ALN) [1] for our collaboration. We design and maintain a website for the online communities. Our approach supports a learning model of constructivism that knowledge emerges from peer interaction, evaluation and cooperation. Moreover, we use the method of role-play between professors and students. Students play a pivotal role in disseminating relevant papers and leading discussion while professors act as in-house referees. After series of discussions and the elimination of

non-working ideas, students and professors collaborate in crafting an abstract paper for a targeted conference.

The order of complexity in carrying out joint research across multiple departments and colleges poses a challenge on two levels: team composition and standard knowledge management system. Recently, we have successfully produced several conference publications [5] co-authored by both professors and students, and have submitted grant proposals. The outcome of research results has placed our team in contact with external funding agencies, such as the National Science Foundation and the Department of Defense. We believe that our collaborative framework is a pioneering model of cross-disciplinary projects and can also serve as a case study for curriculum development.

The organization of our paper is as follows: Section 2 describes the configuration of our collaborative framework. Section 3 explains hybrid collaborative knowledge management system, an application of asynchronous learning network model in the context of our research project. Section 4 assesses the lessons we learned. Section 5 concludes with remarks from the student experience – collaboration and research is hard to teach, but easier to learn in practice [7].

2. COLLABORATIVE FRAMEWORK (CF)

The main drivers for our collaborative framework are to integrate faculty expertise among the various disciplines within the CUNY campuses and to involve students in the forefront of quantum information science. The goal is to develop a pilot knowledge management system for interdisciplinary learning and assess the outcomes. The innovative structure of our collaborative framework (CF) consists of role-play and a hybrid mode of the learning process via a web-mediated knowledge management system.

Role-play involves professors and students in which each takes turns selecting papers of mutual interest and in leading discussions of those papers. The meeting takes place weekly. While role-play is an important innovation in research collaboration, one student is designated as an assistant to maintain the web-mediated knowledge management system (KMS). Whenever relevant, professors would select

the pre-print papers for the targeted research. Our web assistant would post the paper and update the KMS. The local KMS acts as a filter for the electronic bulletin board that disseminates timely and relevant research topics. Two other modes of communication are e-mails, and telephone.

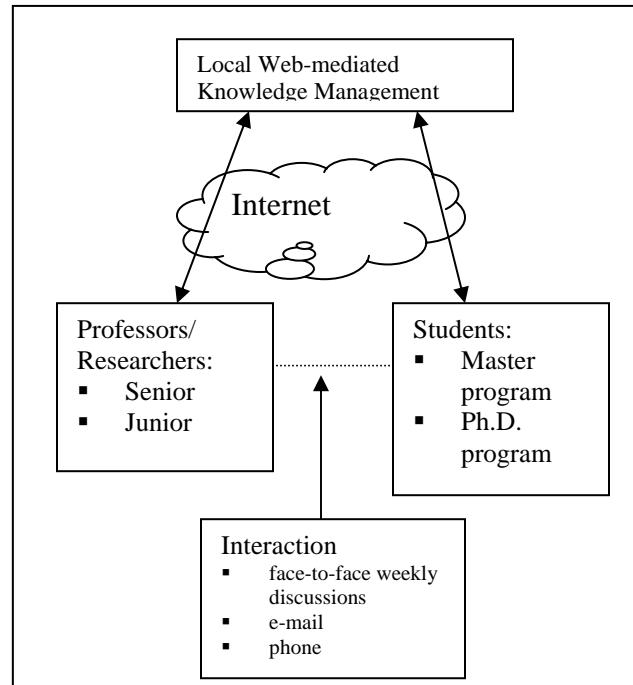


Figure 1: Architecture of Collaborative Framework

A typical cycle of the collaborative framework process begins with a research question. Professors initiate interaction with the students in the intellectual discourse by selecting certain major papers for exploratory discussion. Students accordingly choose subtopics within the research question, and advance the subtopics with more specialized papers. While students gradually become active participants in a specialized area of research, professors slowly adopt the role of in-house referee in discussion and mentor the independent research capability of students. The turnaround time of the role-play process, from initial step to the completion, takes approximately 6 to 12 months.

Figure 2a and 2b demonstrate a case study on the pool of participants, students and faculty, in Fall 2005.

Programs	GC	CCNY
CS	6	3
EE	0	3
Math	7	1
Phys	3	0

Figure 2a: Pool of students in master and Ph.D. program

CS: computer science; **EE:** Electrical Engineer; **Phys:** Physics

Expertise (Prof/Student)	GC	BMCC	CCNY	CityTech
CS	0/6	1/0	1/3	1/0
EE	0/0	0/0	0/3	1/0
Math	1/8	0/0	0/0	0/0
Phys	1/3	0/0	0/0	1/0

Figure 2b: Faculty Expertise and Student Interest grid by campuses

GC: Graduate Center; **BMCC:** Borough of Manhattan Community College; **CCNY:** City College of New York; **CityTech:** New York City College of Technology

CF is comprised of two primary groups: professors, consisting of senior and junior scientists, and graduate students from master and doctoral programs. Due to the interdisciplinary nature of the research and seminar, a professor can have more than one area of subject expertise.

3. HYBRID COLLABORATIVE KNOWLEDGE MANAGEMENT MODEL

Web-mediated knowledge management systems do much more than just transmit discussion-related materials. The online community extends beyond simple scheduled seminar sessions.

The web-mediated knowledge management system leaves behind software artifact that demonstrates the constructive process of knowledge acquisition and generation through peer interaction, evaluation, and cooperation. The audit trail of research progress—what subjects have been pursued and fruitful, and which subjects have led to dead-end valley can be a useful heuristic indicator for new graduate students who want to participate in the research group. Often, such artifact can be used to identify whether pedagogical assumptions embodied in the teaching/learning model are accurate or effective.

Our web-mediated knowledge management system is specifically designed with a set of core focuses, though with the modest goals in mind, to be in touch with the frontier of quantum information science and publishable results.

Web-mediated KMS provides place-independent and time independent knowledge-sharing. Lifting the geographical constraint and time constraint, web-mediated KMS enables researchers of different expertise to participate and contribute ideas. It facilitates collaborative research; improve in-depth reflection, strengthen formulation of comments, and encourage development of new topics.

3.1 Structure of Web-mediated Knowledge Management System

We build a web-mediated depository knowledge management system that keep tracks of two years of seminar papers. Our knowledge management system can trace the focus of each semester and number of students' presentations at the end of the semester.

Since our collaborative framework focuses on interdisciplinary topics and quantum information science, our knowledge management system tracks and recommends other relevant and engaging seminars at the Graduate Center. Often those recommendations are made by professors and occasionally by students.

Structure of the web-mediated KMS:

- Syllabus
- Weekly schedule of seminar topic jointly developed between professors and students
- Other also-of-interest seminars at Graduate Center, NYC
- Announcements of Conferences
- URL to previous semester web-mediated knowledge management system

Figure 3: Structure of web-mediated knowledge management system

One key characteristic of our collaborative framework is that our research group periodically participates in the public meetings of dissertation defenses of mathematics and computer science departments at the Graduate Center. Our knowledge management system [8] keeps track of numbers of dissertation defense, lectures and those students who participated in our research seminars.

4. LESSONS LEARNED

Our collaborative framework not only helped to build bridges with other organizations as well as foster enthusiasm among students and faculty but also produced the following presentations and published papers at International/National Conferences, and a CUNY Collaborative Research Grant Proposal.

- 1) “Post-quantum key exchange protocols”, has been presented and published in the Proceedings of SPIE Defense Security and Symposium, Quantum Information and Computation IV conference, Orlando, FL, April 17-20 2006. quant-ph/0603230
- 2) “Study of Hybrid Quantum Walk Algorithm,” a CUNY Collaborative Incentive Grant Proposal was submitted on April 28, 2006.
- 3) “Development of a Security Education Program at a Minority Institution” has been presented and published in the Proceedings of the 10th Colloquium for Information Systems Security Education (CISSE), Washington DC, June 5-8, 2006. ISBN 1-933510-98-6
- 4) “To Quantum Walk or Not?” has been presented, and accepted for publication in

the Proceedings of the International Conference on Complex Systems (ICCS), in Boston, MA, June 25-30, 2006.

- 5) “On Nash Connectivity and Choice Set Problem“, has been presented, accepted for publication in the Proceedings of The International Conference on Complex Systems (ICCS), in Boston, MA, June 25-30, 2006.
- 6) “A Chaotic Cipher Mmohocc and Its Randomness Evaluation” has been presented and accepted for publication in the Proceedings of The International Conference on Complex Systems (ICCS), in Boston, MA, June 25-30, 2006.
- 7) “A Framework on Collaboration: an Interdisciplinary Project across Multiple Colleges“, has been presented and published in the Proceedings of The First International Symposium on Knowledge Communication and Peer Reviewing (KCPR 2006), Orlando, July 20-23, 2006.

5. CONCLUSIONS

This paper mainly describes the experience of Ph.D. students who participated in the collaborative framework. In addition, all the co-authors of this paper have participated in collaboration projects. Our web-mediated knowledge management system and technique of role-play among professors and students overcomes some of the common challenges [9] in cross-campuses collaboration and interdisciplinary peer review process. This study and review clearly demonstrates that collaboration research across multiple campuses is possible and can be successful, provided that the composition of the team is collegiate and the knowledge management system is monitored on a timely basis.

Acknowledgement: We would like to thank the Department of Defense (DoD), National Security Agency (NSA), National Science Foundation (NSF), PSC CUNY, and all the participants for their supports and valuable comments.

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