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Self-Reflective Essay for Promotion Application

Over the past five academic years, I have been honored to serve as Associate Professor of Chemistry with tenure at Michigan State University, with a 75% appointment in Lyman Briggs College (LBC) and a 25% joint appointment in the Department of Chemistry/College of Natural Sciences. I joined MSU after eight years at King's College in Wilkes-Barre, Pennsylvania (a private liberal arts institution with ~1500 students), where I was Assistant Professor from 1996 to 2002, and Associate Professor with tenure from 2002 to 2004. My responsibilities at MSU, as indicated in my employment contract, are broken down as follows: 5/12 teaching, 4/12 research, and 3/12 service. This self-reflective essay will outline my professional accomplishments in each of these areas, in sequence, as part of my application for promotion to Full Professor.

Teaching

My primary teaching responsibility within LBC is the General Chemistry LB 171/172 sequence. Throughout my five years at MSU I have aimed for a "fun but tough but fair" approach. I tried my utmost to tie the material to real-life situations, focusing heavily on its relevancy to medicine, technology, and environmental science, and using frequent chemical demonstrations including an explosion now and again. Students on the whole seemed to appreciate my enthusiasm for chemistry and my informal delivery style and off-beat sense of humor.

Since my arrival at LBC, the LB 171/172 courses have undergone substantial curricular revision. Instead of having students rely on memorization or training them to do certain types of problems, Dr. [redacted] and I have planned the curriculum to attempt to have them develop more chemical intuition. We emphasized quantum mechanics as the fundamental underpinning of how the periodic table was constructed, why atoms form molecules and ions, and how and why molecules react and have the physical properties they do. After a two-week review of chemical arithmetic, such as equation balancing and stoichiometry, the "meat" of the course began by building up the atom from subatomic particles, focusing on a basic quantum mechanical explanation of electron energies and orbitals. We then moved into periodic trends, specifically highlighting electronegativity, one of the most crucial concepts in the entire chemical discipline. Chemical intuition into structure and bonding was developed via the use of Lewis Structures, molecular geometry predictions, and orbital hybridization (using common pharmaceuticals as case studies in chemical bonding patterns). The course then went into a two- to three-week introduction to organic chemistry. We spent a significant amount of time tying organic concepts of reactivity and chirality to pharmaceuticals and biochemical aspects, and the students worked out some rudimentary multi-step syntheses using "road map" worksheets. We then used some of the organic chemistry reactivity (instead of the usual more boring inorganic precipitation chemistry) to launch into elemental analysis, stoichiometry, molarity, and titrations. Organic chemistry was also a launching point for the discussion of intermolecular forces. LB 171 closed with an introduction to thermodynamics, focusing on enthalpy and the energy stored within chemical bonds, using organic or biochemical reactions as case studies.

LB 172 has commenced with a treatment of the gaseous, liquid, and solid states of matter, allowing for a natural progression. The solid state section was supplemented with a simple explanation of band theory to permit discussion of conduction and semiconduction, crucial to modern technological materials. Kinetics and equilibria were then presented, with a detailed look at acid-base chemistry. Again organic and biochemical reactivity were highlighted throughout these sections. For instance, SN1 and SN2 reactions were reviewed from the organic unit, and tied into reaction rate orders.

The course concluded with a treatment of electrochemistry and nuclear chemistry, highlighting geopolitical and medical aspects of the latter topic. Throughout the course, heavy use of concept maps is made, emphasizing that a correct conceptual approach is an essential foundation to necessary mathematical rigor.

One of the most important changes to LB 171/172 was the institution of group projects on societally relevant aspects of chemistry. In the first semester, the project involves a presentation/poster/in-class debate regarding various alternative energy sources. In the second semester, the project format is similar, but involves the pros and cons of a controversial chemical or pharmaceutical.

Another important addition to the LBC Chemistry course is the use of CPS clickers, which were utilized both for "quick check" content mastery questions, and long multi-step problems solved in a group setting in preparation for course examinations. The students seemed to genuinely enjoy using this system, and moaned a bit if no clicker questions were done in a given class. I appreciate the ability to monitor how long a problem is taking, instead of relying on the faster/brighter student to pipe up "I'm done" and then going over the problem. The CPS system allows alpha-numeric input, instead of just multiple-choice like iClickers.

Because chemistry is a cumulative subject, weekly problem sets and quizzes were assigned to force the students to stay on top of the material in between exam cycles. In the past some of the better students have complained that recitation is a "waste of time" for them, because they were able to tackle even the difficult questions on the problem sets. Having recitation quizzes (which add up to a full exam over the semester) did a good job of enforcing attendance, but we wanted to avoid student resentment about recitation format. Some students had also suggested on their SIRS forms that they wanted more direct exam practice. To address these concerns, recitations in LB 171/172 now involve group-based problem solving activities, working prior year's exam questions that deal with the material covered during the week. The undergraduate LAs circulate among the groups and provide hints and explanations where necessary. Additionally mock exams and worked solutions are placed on the course ANGEL site prior to the exams.

On an experimental basis, required online homework through the Mastering Chemistry system has been instituted across all sections of LB 171/172 for the 2009-2010 academic year. An optional pilot project with this system was done in Spring 2009, and student reviews were largely positive. It remains to be seen whether student learning outcomes will improve now that individualized online homework is required, instead of written out and submitted homework

The course exams in LB 171/172 consisted of written-out conceptual answers and multi-step problem solving, instead of multiple choice/recall questions. I graded all the exams myself, refusing to delegate this work to TAs or LAs. I gave partial credit for showing concept maps/flowcharts for problems that were not necessarily completed; on some exams, writing a correct concept map WAS the actual question. It was more work for me to grade these non-multiple-choice tests, however I felt it was necessary in order to see for myself what the students were easily mastering and what they were struggling with and why. I don't want to remove myself from my students' thought patterns and hear about common errors second-hand.

I have also taught CEM 141/142 in my joint department. While the curriculum is externally set and the parameters more rigid, I have brought the same style and enthusiasm to the teaching that I have in Briggs. I have led the re-formatting of recitation in these courses, successfully bringing in the group-based recitation worksheet format from Briggs. Recitation attendance has risen three-fold, although as of this writing, any effect on exam performance is yet to be determined. When teaching CEM 142 in the summers, I used the written-out exam format, which permits partial credit. SIRS ratings and student comments in these courses were also extremely strong.

Throughout I made myself very available to students, with six office hours per week and others by appointment. I was also reachable via email, Facebook chat, and AOL Instant Messenger (AIM). Many students use AIM and Facebook to converse/play/work with each other. They found it a great way to contact me (sometimes after hours or on weekends) if they needed coaching on homework problems or some clarification while studying for an exam. Sometimes these cyberchats veered off towards major or career choices, and informal discussions about "life, the universe, and everything". SIRS comments have recognized my cyber-availability; students seemed surprised that they could communicate with their professor in this manner.

I am currently developing a LB 492 senior capstone course concerning "Advanced Materials", which will debut in the Spring 2010 semester. This will address the structural and physical chemistry of important technological materials such as steels, semiconductors, ceramics, polymers, and glasses, along with their impacts on society.

Overall, my SIRS comments showed that the students' interest in chemistry and motivation to work hard was enhanced by my enthusiasm for the subject and the interactive presentation style combining lecture with in-class problem solving. I was pleased to receive a number of "best teacher at Briggs/MSU" comments from students. My teaching accomplishments have been recognized by my peers on the Briggs Advisory Council, who have nominated me in both 2008 and 2009 for the Alumni Club of Mid-Michigan Quality in Undergraduate Teaching Award.

Research

Advances in technology have always been predicated on the discovery of new materials. This axiom has held true for millennia: from the harder tools and weapons of the Bronze Age to the high-speed computing and communications of the present Silicon Age. Over the past 13 years my *undergraduate-only* research program has focused primarily on the discovery of novel inorganic/organic hybrid materials called coordination polymers. Coordination polymers are formed from the linkage of positively charged metal ions by neutral and anionic organic molecules, thereby constructing molecular chains, layers, or networks. These solids are finding burgeoning use as substrates for hydrogen storage, shape-selective small molecule separations, ion exchange, catalysis, optical, and magnetic applications. The work has also provided an outstanding introductory research experience for over 40 undergraduates and even some high-school students.

More specifically, my research has involved the synthesis, structural characterization, and physical property measurements of coordination polymer solids incorporating kinked, flexible, and/or hydrogen-bonding capable nitrogen-base dipyridyl neutral ligands, such as 4,4'-dipyridylamine (dpa), 4,4'-dipyridylketone (dpk), and bis(4-pyridylmethyl)piperazine (bpmp) (See Figure 1 in Form D Appendix, please download from my Supporting Information on ANGEL).

I began this coordination polymer research program at King's College, as it strikes the balance between being a very feasible project for undergraduates and being able to produce high quality, publishable science. The research at King's produced 16 peer-reviewed articles between 1996 and 2004. Since arriving at MSU, I have hosted 30 undergraduate research students, many of whom have been extremely productive. The result of their outstanding work has been 88 peer-reviewed publications (59 papers/communications, 28 structure reports, 1 review), many in high-rank journals such as *Inorganic Chemistry* and *Crystal Growth & Design* (published by the American Chemical Society), *Dalton Transactions* and *CrystEngComm* (published by the Royal Society of Chemistry, UK), and the *Journal of Solid State Chemistry* and *Polyhedron* (published by [redacted]. Nearly all of these publications have one or more undergraduate co-authors. I have garnered three external research grants in support of this work (Research Corporation and American Chemical Society Petroleum Research Fund), with a grant from the latter organization now in force.

Traditionally, the most common neutral linking ligand in coordination polymer chemistry has been 4,4'-bipyridine (bpy), which enforces a "rigid-rod" connection between metal ions. Our work has led to substantial success preparing coordination polymers containing kinked, flexible, and hydrogen-bonding capable pyridyl ligands, nearly all of which display structural topologies markedly different from their 4,4'-bipyridine analogs. Several of these materials possess completely novel topologies, including some with unprecedented "self-penetration" mechanisms wherein the molecular structure is essentially woven in on itself. We have also been probing the structural effects of alkyl group substitution within flexible dicarboxylate ligands, an under-investigated aspect in coordination polymer chemistry. In these cases, radically different magnetic properties have been induced due to the resulting structural alterations, when compared with unsubstituted analogues. Through our work, the scope of coordination polymer topologies has been expanded. As the direct design and *a priori* prediction of coordination polymer topology and properties are still largely in their infancy, synthesis-driven discovery of novel coordination polymer topologies remains an essential basic research pursuit.

As some brief examples of my group's research, coordination polymers incorporating divalent metal cations, phthalate anions and kinked, hydrogen-bonding capable dipyridyl ligands manifest exceptionally intriguing structures with a significant diversity of physical properties. A copper phthalate/dpa coordination polymer adopted a striking chiral septuple helical "nanobarrel" topology based on linked Cu_2O_2 units (Figure 2), with hydrophobic aromatic rings projecting into and out of the nanobarrel. Ferromagnetic coupling (parallel alignment of electron spins) was observed within the Cu_2O_2 units. When using dpk, the reversal of the hydrogen-bonding mechanism from donor to acceptor resulted in a switch to a three-dimensional cage structure, albeit based on similar Cu_2O_2 units. Moreover, this topology represented the first example of a three-dimensional Kagome-type lattice of connected trigonal and hexagonal tilings (Figure 3) ([redacted], [redacted] *Inorganic Chemistry*, **2009**, *48*, 4918–4926). The structural adjustment resulted in a change to antiferromagnetic behavior (opposite alignment of electron spins) within the Cu_2O_2 units. Use of the larger divalent cadmium ion afforded a chiral, self-penetrated topology, built from the mutual interweaving and junction of three individual self-penetrated lattices (Figure 4). This cadmium-based material underwent blue-violet visible light emission upon excitation with ultraviolet light, ascribed to electronic transitions within the molecular orbital manifolds of the aromatic ligands (see [redacted] *Inorganic Chemistry*, **2009**, *48*, 2723–2725). In conjunction with flexible, aliphatic dicarboxylate ligands, the dpa ligand was able to promote some striking topologies. A nickel succinate dpa coordination polymer was the first example of a regular 5-connected network: each nickel atom joins to five others, and all nickel-organic rings in the structure contain six nickel atoms. In order to achieve this connectivity pattern, which had eluded mathematical a priori prediction of regular networks, the structure self-penetrates in an unprecedented fashion via the junction of four independent diamond-type lattices (Figure 5) (see [redacted] *Crystal Growth & Design*, **2007**, *7*, 1145–1153). Future work in the group will involve the use of longer, more flexible pyridyl ligands, which will provide substantial synthetic challenges for the undergraduate researchers. Once these ligands are in hand, we expect to obtain a plethora of coordination polymer phases with novel topologies, along with empirical knowledge concerning the effects of tether length and hydrogen-bonding facility on structure and luminescent, sorptive, and/or magnetic properties.

We have also begun to investigate the synthesis, characterization, magnetic properties and chemical reactivity of a series of low-coordinate transition metal and lanthanide metal molecular complexes bearing bulky anionic tungsten-based *tert*-butylimido metalloligands. This work will have potential applications towards molecular magnetism and organic transformation/polymerization catalysis. Preliminary work has been fruitful, with the characterization of antiferromagnetically coupled MnWMn, FeWFe, and CoWCo type trimetallic species, which are rare examples of molecular species containing two trigonally coordinated paramagnetic transition metal ions (Figure 6). A manuscript submission on this newer molecular-based work is planned for *Inorganic Chemistry* or *Dalton Tranasactions* in the near future.

The group's work has attracted international notice, resulting in manuscript invitations from the Editors of *Polyhedron* and *CrystEngComm* for forthcoming "New Talent" special issues. (The *Polyhedron* special issue article is in press as of this writing.) Last year, I was invited to write a review article on the group's research for *Coordination Chemistry Reviews* (impact rating 10.56, highest in inorganic chemistry), which was published in the summer of 2009. Citations of the group's work are becoming more numerous. Three of the group's recent articles were among the Top 10 monthly downloads on journal websites, including the #1 featured ASAP article at Inorganic Chemistry's website in April 2009. In July 2008, the work of [redacted] a McNair/SROP scholar in my laboratory, was featured as the Cover Article for *CrystEngComm* (impact rating 3.5, second highest journal in crystallography). In August 2009, I presented a paper concerning the group's recent work at the 42nd Annual Congress of the International Union of Pure and Applied Chemistry, in Glasgow, Scotland. Unfortunately my attendance/presenting at American Chemical Society National Meetings has been precluded by my responsibilities as a single father in the mid-August to mid-June academic year timeframes.

My research group has hosted undergraduate researchers drawn from an ethnically- and gender-diverse pool of LBC and CEM students, along with talented high schoolers. I accept no graduate students or postdoctoral fellows by design, as one of my overarching professional passions is mentoring undergraduate researchers and helping them blossom into independent scientists. Participants have also come from the McNair/SROP and HSHSP programs.

Because of the unique nature of my undergraduate-only coordination polymer research program, there is a substantial cross-cutting element between the teaching and research aspects of my professional role. The undergraduates who participate in the project develop proficiency in traditional organic synthetic techniques while preparing many of the necessary anionic and neutral linking molecules, along with basic analytical techniques for product identification (infrared, mass spectrometry, nuclear magnetic resonance). They perform all of the coordination polymer synthesis, as they attempt to optimize often unpredictable synthesis conditions (temperature, time, concentration, solvent, pH, pressure); in many cases careful control of conditions is necessary to achieve reasonable product yields. The students also learn how to perform the single-crystal X-ray crystallography necessary for the precise determination of molecular structure, including crystal selection, unit cell and symmetry determination, data collection optimization, structure solution and refinement, topological analysis and identification, and molecular graphics rendering. They also perform the variable temperature magnetic susceptibility studies and learn how to model the behavior using statistical analysis software. I provide substantial hands-on techniques guidance as the students work towards independence. I maintain a constant presence within the research laboratory, choosing not to have a separate office in order to provide better in-person mentoring. Advanced students have become involved in manuscript composition for journal submission; all learn how to search the scientific literature for related prior work. Beyond the substantial experience they receive in the techniques of chemistry and experimental design, the students attain a high level of scientific independence and maturity early in their careers.

I derive special personal satisfaction from the high achievements of many of my undergraduate research students. Three of my students have garnered more than ten peer-reviewed publications. [redacted] and [redacted] have won First Prizes in the Physical Sciences competition at the University Undergraduate Research and Arts Forum (UURAF); [redacted] and [redacted] have won Second Prizes. [redacted] was invited to present at the National meeting of McNair/SROP Scholars, and is now enrolled in a graduate program in Mathematics Education at the University of Michigan. One of my HSHSP students, [redacted] earned semi-finalist status in the Intel Science Talent Search in 2006. His success was exceeded by that of [redacted] my HSHSP student in the summer of 2008. His work resulted in five publications, including the aforementioned #1 ASAP article at *Inorganic Chemistry*. [redacted] was a Finalist in this year's Intel Science Talent Search, making a presentation before scientists and political figures in Washington, DC, along with a short personal meeting with [redacted] A biographical piece about [redacted] has appeared in the September 2009 issue of *Chicago Magazine*, as part of a feature on six high-achieving Chicago-area teenagers (a PDF copy of this article can be downloaded from my Supporting Information folder on ANGEL). Eight of my former researchers are now pursuing or have completed Ph.D. degrees chemistry: [redacted] (University of California at San Diego, current), [redacted] (University of Chicago, current), [redacted] (Cornell University), [redacted] (both University of South Carolina), [redacted] (all Syracuse University). Others have pursued medical school or industrial careers upon graduation.

Service

While undertaking many of my service responsibilities over the past five years, I have sought to integrate the teaching and research components of my professional role. Many of my community service and outreach engagements were ably assisted by Honors Option students in my LB 171/172 sections, who found the service learning opportunities very rewarding. Much of my discipline-focused service work has involved grant and manuscript reviewing, which helps to keep me abreast of developments and upcoming trends in my research field. In this section of the self-reflective essay, I will address my service roles towards my research discipline, MSU, LBC, and the wider community in sequence.

I have reviewed approximately 150 manuscripts for international chemical journals, including Journal of the *American Chemical Society, Chemical Communications, Inorganic Chemistry, Dalton Transactions, Crystal Growth & Design, CrystEngComm, European Journal of Inorganic Chemistry, Journal of Solid State Chemistry, Polyhedron, Inorganica Chimica Acta*, etc. I have reviewed some pedagogically oriented submissions to the *Journal of Chemical Education* as well. I have also served as an external reviewer for scientific and instrumentation proposals for the National Science Foundation and the American Chemical Society, including as an on-site panel reviewer for NSF. I have also assisted publishing companies as a consultant, proofreader, solutions checker, and reviewer for several General Chemistry textbooks. For three years I was co-Coordinator of Chemistry Day at Impression 5 Museum, the annual observation of National Chemistry Week hosted by the MSU Local Section of the American Chemical Society.

In the wider University, I have served on the CNS Curriculum Committee and on the All-University Traffic and Transportation Committee (co-chair of Vehicular Safety and Parking subcommittee), and was one of the faculty members on the job search committee for a University-wide Coordinator of Undergraduate Research (resulting in the hire of [redacted] I have also hosted a Chemical Demonstration class for Grandparents' University since the program's inception. I have judged the Physical Sciences poster competition of the University Undergraduate Research and Arts Forum on several occasions.

Within Lyman Briggs College I have participated in ad-hoc committees for LBC Laboratory Renovation, RPT rubrics, and individual RPT and mentoring committees for fellow faculty members. Currently I am serving on an ad-hoc committee that is working towards replacement of the standard SIRS course evaluations with a SALG (Student Assessment of Learning Gains) instrument that will hopefully better reflect student learning outcomes. I have worked on several job searches in both Chemistry and HPS (History, Philosophy and Sociology of Science). In most recent years I have organized the orientation workshop for new Learning Assistants in chemistry, mathematics, biology, and physics. I also delivered the Faculty Address at the 2008 Lyman Briggs graduation brunch, by senior-class invitation. Additionally, I have delivered guest classes in LB 290 (preparative science class for those with weaker math/science backgrounds) and in LB 133 on three occassions (on ethics in grant awarding, and as someone who could provide a reasoned politically conservative viewpoint on bioethical matters.)

I have been extremely active bringing the excitement of chemistry and science to the general public, especially to elementary-school age chlidren. I have hosted a very well-received Chemical Demonstration show as part of Grandparents' University each summer since 2006, and helped to organize Chemistry Day from 2004 to 2007.

I have also performed three-to-five demonstration exhibitions each semester at area elementary schools, assisted by LB 171/172 students earning Honors Options credit for their service learning work. Each semester, along with an LB 171/172, I hosted "touch and feel" exploratory sessions for mentally handicapped and autistic children at Pinecrest Elementary School in East Lansing.

While not directly related to my professional chemistry-related activities, for ten years I was the president of the not-for-profit North East Art Rock Festival, which occurs every late June at Lehigh University in Pennsylvania. The festival hosts national and international artists in a non-commercial music style melding modern rock with classical and jazz, and has sold out each of its 11 years in existence. (www.nearfest.com). I also spearheaded an art-rock benefit CD project for Habitat for Humanity in response to the aftermath of Hurricane Katrina, whose proceeds funded construction of a new residence in the New Orleans area.