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Skill Development with Students and Explicit Integration Across Four Years of the Curriculum

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The 2005 Alan Blizzard Award

Section A: Information

1. Descriptive Title of Project

Skill Development with Students and Explicit Integration Across Four Years of the Curriculum

2. Period of Implementation

Academic Year	Inquiry I	2001 – Present			
		Psychobiology	Upper Level Courses		
	10 iterations	5 iterations	4 iterations	3 iterations	1 iteration
2000 – 2001	4 sections				
2001 – 2002	6 sections				
2002 – 2003	8 sections				
2003 – 2004	9 sections			3H03 Inquiry Project	
2004 – 2005	9 sections		2E03 Inquiry Year II 2K03 Cell Biology Inquiry 4X03 Collaboration & Peer Tutoring Inquiry	4D03 Special Topics in Health Sciences Inquiry I 4W03 Special Topics in Health Sciences Inquiry II	4AA3 Group Dynamics

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January 2005

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Section B: Nature of the Collaboration

The Group was brought together in the summer of 2000 to develop the curriculum for Year One of a new undergraduate Bachelor of Health Sciences (Honours) degree programme (http://www.fhs.mcmaster.ca/bhsc/). Participants self-identified and in truth, no one connected with this nomination is required to participate at any level. We set goals and sketched a framework for Year One. We began to meet at 7:30 am, once per week, to share experiences and examine our activities. At the end of Year One, we held a three day retreat with students and staff and reflected on the experience and refined the goals. The goals are still being refined. We still meet for breakfast at 7:30 am and we have held two to three retreats per year, always with students. The group developed a learning space for student success and recruited a doctoral candidate to formally study what we were doing; she also teaches. Some of what we do changes by discussion but we try to ensure that the discussion is evidence-based. The vision was to set a framework for students that dealt with competencies required of self-directed, lifelong learners who would have effective group skills. As we progressed, the group took responsibility for integration of the Year One pedagogy into each of the next three years of the programme; effectively, skill development across courses and years. In their final year, students join us as peer tutors and close the circle of reflection in that they are now also facilitators. We have engaged in serious reflection, team teaching, working with instructors from other programmes to allow them to take the experience back to home departments, and persistent, scholarly examination of what we do. Perhaps in part, we are informed, in that all of us had or have, significant struggles with the same skill set (i.e., group work, time management, self-evaluation, following through), are able to recognize the concerns and solutions and are able to facilitate the development of each other and students. The product of the group is truly a learning community.

Section C: Project Abstract

How would an educational narrative unfold if we had specific and explicit goals to develop an entire programme for undergraduate students that promoted the ability to identify and solve problems, to think critically, to work in groups and to communicate more effectively? Here is an actual snapshot of how this story is being written in the BHSc Programme at McMaster University:

> I learned today that I was accepted into the McGill Bioethics Programme. An interesting situation considering they initially said I had to be from a professional programme. I guess I made quite an impression at the bioethics meeting. I seemed to be the only one asking questions at dinner.

> Looking back at my education in the McMaster BHSc Programme, I now see why my education was so different from my peers. The difference was that it was me who learned to define my needs and match them to opportunities. It started in Inquiry 1E06. My facilitator was Margaret Secord. What a live wire. I had no idea what was going on. She gave me a course outline and a time to meet but did not tell me what to do or give me

any deadlines. She told me that the course was focussed on skills. I would have to meet with Margaret four times over the year to discuss evidence supporting my ability to self-evaluate my skills and knowledge. I quickly learned that my ability to do this was much weaker than I thought. I would have to negotiate a mark based on a review of evidence. I could not even figure out what evidence she was talking about.

Our class was divided into groups of five and my group interviewed a standardized homeless person. The group was supposed to explore a question. What question? She did not tell us and it took awhile to get going. In the end, we had answers to questions but that was not really what we learned. We learned to work with each other, to ask questions, to find answers, to think about the answers. By the end of the year, I had a better understanding and I knew that I had grown in so many ways. I was *not* looking forward to lecture courses. Were there any more opportunities like this?

The rest was fun. I worked in groups in second year Inquiry and Cell Biology. I learned to learn, to know what was important and what was not. They used the same evaluation models and a great deal of reflection was required. In third year, I built my communication skills with Carl deLottinville and then went to South America to satisfy my learning objectives in a community clinic. As I ran out of Inquiry courses, I asked for new ones so I could "get my learn on". I reinforced it all with my skill set as I went along and, from where I sit now, I can see that I am a much more mature learner than many students I know from other Faculties. I think I will stay in school, my school.

Section D: Project Description

Ninety-nine percent of college students express belief in at least one paranormal phenomena including, psychokinesis, UFOs, plant consciousness and ghosts (Messer and Griggs, 1989). By some estimates, Ontario could save close to 10 billion dollars in health care costs by dealing with the issue of inappropriate use of prescriptions. This may be related to studies that have demonstrated that the average physician interrupts a patient 23.1 seconds into a conversation when it is known that the average problem takes 90 seconds to describe (Marvel et al., 1999). We will return to these issues at the end. They are the trigger that frames why we need to do more serious facilitating of inquiry, in the same way that a trigger for Harvard was the inability of Science graduates to explain the four seasons.

Perhaps some of these issues are simply the substance of humor but conceivably they are, in part, a reflection of education practice. We, as educators, often speak of the need to change the practice of teaching. Understanding the complexity of our global experience compels us to adapt. One way to begin is to make a concerted effort to examine evidence of best practice and either implement, reject or tailor practice to particular learning problems. However, without marshalling this evidence together with a vision of creativity and collaboration, risk and respect, education will fail us and future generations. We speak of active learning, lifelong learning, problem-based learning and inquiry-based learning but most of us find it difficult to implement alternative pedagogies or even understand how they were implemented by someone else. Perhaps we can never teach because we do not understand all that well, how people learn.

Learning is the activity and product of learners and may or may not have as much to do with us as teachers as we might think. We place value on helping students to be more self-directed, better critical thinkers, clearer communicators, better knowledge constructionists and more inquisitive and socially conscious citizens. The goals are right but it is possible to argue that we just are not confident enough with how to do this. Maybe we spend too much time trying to control the learning, or do we treat outcomes as implicit variables in how we teach and assume that they occurred? Most of us, particularly those of us who think education is the most difficult passion you can have, struggle with all of these issues and see change as something that will require systemic change of practice. The challenge: conceptualizing the system, understanding its dynamic forces and restraints and figuring out how changes in the system bring about desired outcomes.

We do not know that we have answers. We do have access to a rich body of education research, but the context of what we see in the literature feels so disconnected from the places in which we practice. The answers begin to emerge when we embark upon well contemplated, systemic and sustained experiments with students and faculty. The experiments, for want of a better term, deal with how we teach in Year One of the Bachelor of Health Sciences (Honours) Programme (BHSc Programme) at McMaster University and how we use the first year experience to imbue a sense of community and explicitly inform the curriculum and learning that follows. We will always be experimenters and in fact, the curriculum always changes. Therefore, this communication is a snapshot of a rich environment that cannot capture the growth and detail of all of the various elements. We do know that our values are imbedded in student self-directedness, abilities that combine skills with knowledge, deep, not surface learning and deeper thought on the

issue of lifelong learning. We know the students and we challenge them. We are seeing the system change.

Context (McMaster University)

The BHSc Programme is a competitive entry programme from secondary school that is designed to offer biological, population and behavioral perspectives on health; the rough equivalent of a science programme in a Health Sciences Faculty (http://www.fhs.mcmaster.ca/bhsc/). The Programme at McMaster is in the fifth year of operation and is designed around Inquiry style courses that are offered at each level. We have had at least four iterations of most of the elements described in this document. With respect to Year One Inquiry there have been ten iterations (thirty-six sections of twenty students over five years). Various elements change every year. The Programme had its origins in a series of meetings in 1999. In the summer of 2000, a number of individuals volunteered to facilitate with the first cohort in Year One Inquiry and worked initially to set goals for themselves and for students. This group has persisted, has developed something successful to celebrate and has changed how we think about and design upper level courses. Our experience is illustrated in our vision of what we would like students to 'look like' after four years of university in an undergraduate programme. The outcome is that ***Students will have experienced the Health Sciences as a Complex Adaptive System (CAS).*** In approaching the facilitation and process of learning as a CAS, the outcomes we seek to achieve with students are the emergent properties of autonomous and interdependent relationships between students and faculty within a learning community.

One of us (D. Harnish) was involved in the design and implementation of Inquiry courses at McMaster, in Year One, before they were formalized. Inquiry courses, in and of themselves are no longer an innovation as many institutions have adapted and adopted parts of the approach. Nor is it innovative to take large courses and break them into smaller sections or groups, as we have done in many contexts. These things are a natural consequence of treating teaching and learning as a contact sport and of creating those expectations with students. Year One Inquiry in the BHSc Programme is innovative because the CAS design has been the vehicle for continually building and recreating the entire programme. The models practiced in other faculties (Arts and Science, Theme Schools, Humanities, Social Sciences, Science) are different in many important respects and there has been a struggle to inform other Year One or upper level courses. The successes we describe build upon the willingness and enthusiasm of participants for weekly 7:30 am meetings and numerous educational retreats to develop principles, expectations, vision and process that permeates all levels of the programme of studies.

The Goals

1. To develop a learning environment in the context of a review of evidence and scholarly literature and to demonstrate, by evaluation, that the learning environment is better or at least, effective.
2. To develop an Inquiry course that would provide opportunity to develop a specific set of transferable skills as a core experience on which to build an undergraduate, nonprofessional

programme.

3. To allow students an opportunity, in a safe environment, to reflect on personal skills recognizing that failure is sometimes necessary to discover. We are not, here, referring to marks or grades.
4. To invest heavily in student contact in Year One so that new opportunities for deep learning are available in upper years of the programme: both formally in courses and informally. We can spend the same amount of time with them, in upper years, in more productive ways instead of following a lecture schedule.
5. To encourage the development of attitudes and behaviors that are required for self-directed learning and active learning in ways that allow students to take personal responsibility for their learning.
6. To encourage and develop in conjunction with students, effective group skills.
7. To encourage and develop with students a sense of learning communities, in part by developing formal credit for activities outside the classroom.
8. To formally link Inquiry courses and a mandatory Psychobiology course in Year One and continue this linkage with upper level courses.
9. To develop a culture for faculty in which reflection and feedback is a regular activity, encouraged and supported by a group.
10. To develop a sense of explicit competencies expected of faculty members that are necessary in the support of student learning, in the programme context.

Implementation and Active Learning

The focus of this document is on the courses listed in Table 1. In Year One, Inquiry courses focus on skills including, group skills, self and peer evaluation, critical thinking, knowledge management and time management. Year One Inquiry supports, in a reciprocal fashion, Psychobiology, which uses journals, group essays and group work. This starts a process that is integrated into other courses with defined knowledge acquisition requirements. Year Two Inquiry asks students to continue developing their skills in the context of defined knowledge requirements attained in groups of ten. Year Two Cell Biology uses group PBL and videotaped discussions to integrate core knowledge into a group problem-solving setting. Students then measure their knowledge against an expert in the area, in a public forum by asking questions. Skills developed and supported in these contexts then allow students to develop their own learning objectives in a third year Inquiry project structured to meet more specific and personal needs. The Year Four Peer Tutoring and Collaboration course is student-designed and creates an opportunity for students to act as peer tutors in Year One Inquiry or to work in a wide range of other environments over four years, all requiring and reinforcing the transfer and development of inquiry skills. We have had to respond to student needs and requests by creating at least five additional upper level courses built on this framework and in the context of higher levels of self-directedness. We use the same self and peer evaluation tools or themes in all of these settings and reinforce the Year One skill set. All of the courses benefit from a strong implementation of a collaborative e-communications platform and the research that supports it (see LearnLink, below).

TABLE 1. Courses Supported and Developed in the Context of Inquiry.

Level	Course	Percent of the Curriculum
Level I	Inquiry 1E06 Psychobiology 1G03 4X03 Peer Tutoring and Collaboration	20% 10% Variable
Level II	Inquiry 2E03 Cell Biology 2K03 4X03 Peer Tutoring and Collaboration	10% 10% Variable
Level III	Inquiry 3E03 Inquiry Project 3H03 4X03 Peer Tutoring and Collaboration	10% 10% Variable
Level IV	Project or Thesis (4A09 or 4B06) 4X03 Peer Tutoring and Collaboration (credit) Six Active Inquiry Courses (4AA3, 4D03, 4T03, 4U06, 4W03, 4Y03)	30% or 20% Variable 10% - 60%

Context of these Activities within Scholarly Literature

We are informed by a very rich literature, only some of which can be described here. Postman and Weingartner (1969) describe the features of effective inquiry instructors and good learners. Our expectations of facilitators are consistent with their view but we are also developing a set of specific core competencies that we expect of facilitators and we are significantly informed in this by the works of The Association for Specialists in Group Work and Conyne (1999).

Knapper and Cropley (2000) contend that, "nearly all universities claim to espouse lifelong learning goals, but their educational programmes, teaching methods and organizational structures often discourage lifelong learning". Candy et al. (1994) outline some major impediments to implementing active learning strategies that promote lifelong learning including: making extensive use of lectures; overloading the curriculum with too much detail; emphasizing memorization of facts; using over-simplified and outdated models or theories; de-emphasizing connections to skills or real-world applications; not giving appropriate and timely feedback; and not constructing assignments and learning activities that promote library usage (cited in Knapper and Cropley, 2000, p. 175).

Grayson (1999) conducted a survey at York University to assess the 'value added' skills students gained during their university years. The survey asked students to rate their abilities in domains such as communication, analysis, personal organization, comparative basic numeracy and computers. There was a strong correlation between secondary school marks and university cumulative GPA while the correlation between university cumulative GPA and perceived skills competence was weak. Science students, who improved substantially in areas such as computer skills, organizing skills and basic numeracy, reported minimal gains and remained below the mean on analytic, communication, personal and comparative skills. Self-reported gains for analytic, communication, personal and comparative skills were unacceptable to his institution (Grayson,

1999).

Since the late 1980's, there has been a call to implement active learning strategies into higher education teaching and learning and a concomitant imperative for universities to graduate students with critical thinking, interpersonal and communication skills, (i.e., Boyer Commission, National Research Council and the National Science Foundation, Conference Board of Canada). To achieve these objectives, these groups advocate that students should have opportunities to work in small groups with peers to "have access to supportive, excellent undergraduate education in science, mathematics, engineering and technology, and [to] learn these subjects by direct experience with the methods and processes of inquiry" (National Science Foundation, 1996). A meta-analysis by Springer et al. (1999), reviewed the effects of small group learning on science, mathematics, engineering and technology undergraduates. Based on 39 eligible studies, the authors reported higher academic success, decreased attrition from a course and more favourable academic attitudes when compared to control groups who did not experience collaborative or cooperative learning. The link between how active learning strategies moderate students' cognitive and affective academic behaviours are less well established (Slavin, 1996).

The current need in the active learning and inquiry literature is to determine which specific instructor behaviours and course elements have the greatest impact on student learning gains. Researchers, within the educational psychology field, have focused on describing the meta-cognitive skills that small group, active learning strategies appear to promote. The current view is that global thinking skills can be taught provided: the general heuristics have rules and guidelines which are made explicit to the learner as they acquire the skill; are practiced in several knowledge domains; and that learners have opportunities to practice and reinforce the meta-cognition of these skills with other learners (Perkins and Solomon, 1989; Norman, 2002). This captures the intent of the student and faculty group activities detailed in this document.

Four Years of the BHSc (Honours) Programme

Year One Inquiry

This first course is built around groups of twenty students working with one facilitator and four peer tutors. The course is designed to promote the development of skills as detailed in Table 2, using a specific iterative model *IREC (Inquire, Reflect, Evaluate, Construct)* (Figure 1) and a focus on skills, not specific knowledge. We do not test knowledge in the traditional ways but we expect and encourage learning. Much of the learning is personal.
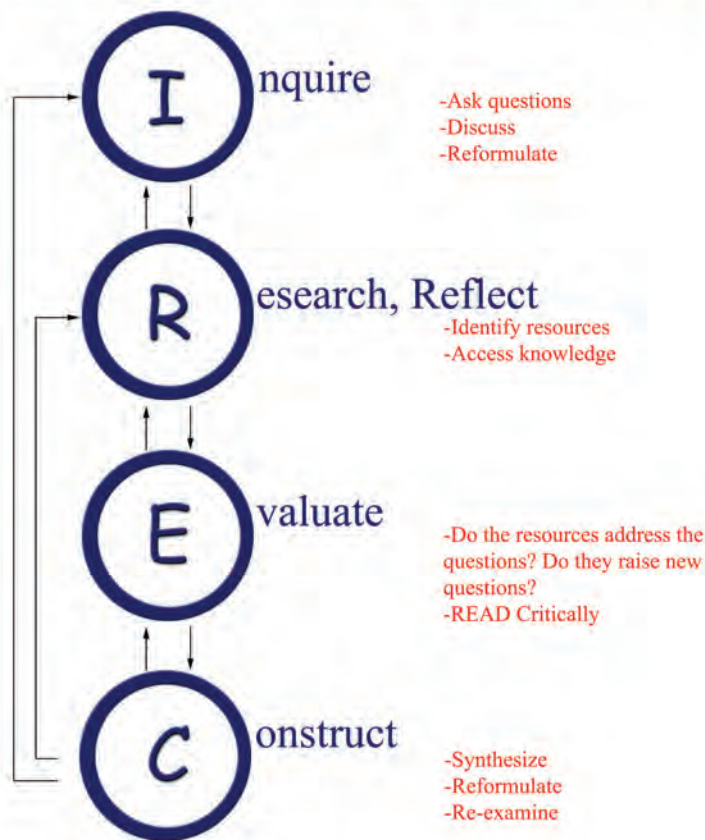
In week one of the course, groups of five students are provided with a Benchmarking Exercise that asks them in a three hour slot to read a scientific abstract, discuss and question the contents and decide on a question the group wants to answer. Students are then asked to go and find an answer. The experience is videotaped. For the most part, students recognize that they can ask questions but do not know how to find, interpret and discuss answers to questions. The materials are stored without formal facilitator review. The exercise is repeated eight months later. Then students are provided with their materials from the first attempt and the materials from the final attempt for review. The review that we encourage is in the context of an examination of whether they

TABLE 2. The Inquiry Skill Set.

Inquiry Skill Set
1. Time management (setting priorities, managing time and staying on track)
2. Posing a good question and refining it
3. Identifying sources of information (library, online indices, World Wide Web and interviewing experts)
4. Evaluating (critical thinking) and integrating information
5. Using information to answer a question
6. Communication skills (verbal, nonverbal and written)
7. Working with another person and a group
a. Identifying individual and group strengths and weaknesses
b. Dividing responsibility
c. Following through
d. Teaching each other and learning from each other
e. Giving and receiving constructive feedback
f. Dealing with minor conflict
8. Evaluating your strengths and weaknesses in each area (formally, informally and often)

FIGURE 1. The IREC Model.

The Inquiry Process (Path to New Knowledge)

I nquire
-Ask questions
-Discuss
-Reformulate

R esearch, Reflect
-Identify resources
-Access knowledge

E valuate
-Do the resources address the questions? Do they raise new questions?
-READ Critically

C onstruct
-Synthesize
-Reformulate
-Re-examine

can identify changes in their skills as a consequence of the course activities over an eight-month period. This exercise captures the expectations we have of students. In the course, they will have significant opportunity to develop and reflect in terms of their learning. They will also have opportunities to develop their ability to evaluate themselves and their peers in the context of the group activities that are necessary to develop skills that encourage learning.

The remainder of first-term is devoted to activities that encourage students to take responsibility for their learning. We do not at any point tell them precisely what is required of them. We are explicit with respect to an expectation that they will change over the course of the year in the context of the skills and this discussion is necessarily a protracted one. For example, we tell students that as individuals they will all have

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different needs and different expectations. One student may have a particular strength in one area and a need to develop in other areas of the skill set. This will be different from the needs of other students in the course.

The vehicle utilized for the development of skills varies from year to year. We have used knowledge areas such as, the influenza epidemic of 1914, homelessness and most recently, an exploration of any question in the context of the dimensions of BaFa BaFa (see below) and schizophrenia. Sometimes we initiate the process with a videotape and for a few problems we have initiated with an interview with standardized patients (SPs). SPs are actors trained in various scenarios. In the third week of classes, we schedule an evening with the 180 students to run a cross-cultural simulation, BaFa BaFa, which provides students with an opportunity to explore problem-solving in the context of learning to practice one of two alternative cultures; either a trading culture or a male-centered culture. This is always an opportunity for them to reflect not just on cultural issues in the broader sense but also how they may solve problems, ask questions, listen, observe or perceive their adaptation to University and the cultural changes that this has required of them.

The various classrooms are very rich. Different facilitators draw on their own personal expertise using a framework of expectations that we have all agreed upon. All facilitators expect substantial reflection from students on the activities that occur both in their small groups and in other courses. Groups of students develop questions in the context of the broad knowledge framework and IREC. As they develop their questions, they will have specific needs including for example, the need to understand how to access resources from a wide variety of alternatives, a need to understand the ways in which libraries and the Internet organize resources and the need to understand various issues around how we think about the credibility of different sources of information. In order to do this well, we specifically work with two librarians on the teaching team. They work actively with students in each course section to provide overviews of these issues. Smaller groups of students then approach the librarians to identify and address specific resource needs over the year and this process continues over four years. For example, student groups will record the methodology they used to find information and then will approach librarians to review the process and assess their perceived strengths or weaknesses. Librarians play an essential role in advising students on how to find high-quality and appropriate resources.

During the first year, students meet individually with facilitators on at least four occasions in the context of self and peer evaluation. This means that students must formally assess their strengths and weaknesses (areas of growth) and provide objective evidence to support their perspective. For example, a student may identify time management as an issue and this will be supported by their anxiety and attempts to complete various requirements of this course and other courses, at the last minute. Instead of sending them to a seminar on time management, we work with them individually to explore appropriate strategies. The final meetings in December and April require students to self-assess using the skill set and to provide evidence for their success or failure in each area. They assign a mark to themselves based on this reflection and the facilitator negotiates a final mark with them by reviewing the evidence (Table 3). They must leave with a plan for improvement in subsequent years.

TABLE 3. Final Mark Descriptors. These are the guidelines used for final mark negotiation.

Grade	Description
A	… has attained a higher level of competency in all, or almost all, of the stated skill areas. This competency would allow the student to complete excellent inquiry projects in any area. This would be recognizable by any facilitator and the peer group. The student is aware of any remaining area of weakness, has shown improvement in that area, has developed strategies for minimizing its adverse effects, and has a plan of action for eliminating the weakness.
B	… has attained a high level of competency in many (but not all) of the stated skill areas, or has attained moderate competency in all of the skill areas. This competency allows the completion of good inquiry projects. The student will have developed a plan of action for further development in those areas which need it.
C	… has attained a moderate level of competency in some of the stated skill areas or has attained a low level of competency in all of the skill areas. The student will recognize the deficiencies or concerns and will have discussed a plan of action to deal with the concerns during their university career.

Psychobiology

One of us (H. Szechtman) teaches this course with 180 students. There are no examinations. Twice-weekly lectures frame the requisite background knowledge in imaginative ways and form the substrate for the students' main learning that occurs in the context of group essays (five students), reflective journals and electronic class discussion. One of us (S. Barrett) has attended the class lectures and the course instructor meets weekly with the formal Inquiry facilitators. Issues pertaining to the writing of a good essay, and the unique aspects of doing this in a group format, are formal topics of discussion in Inquiry and because they are integrated with the Psychobiology timetable are seen by students as providing strong and relevant support for their Psychobiology learning. Similarly, the issues that arise in writing a reflective journal are also supported by Inquiry. Each week students write a three-part journal. Part A is a 200-word synopsis in a paragraph format that highlights the main points of the past week's lecture material.   Part B requires the students to generate and provide a rationale for two "further" questions that the lecture material has raised in their mind. Finally, in Part C students must identify which new information that they have learned contradicts or does not fit with the knowledge that they already possess and how they could go about to resolve this dissonance. During the first five weeks of the course, students receive written feedback on the journals. From the subsequent eight journals, students choose what they believe are their two best entries and these two journals are submitted for formal marking. Finally, students utilize LearnLink to raise questions and discuss how the lecture material relates to everyday experiences, stories they heard, movies they had seen, etc. This 'lecture style' course is explicitly

supported by Inquiry and Psychobiology incorporates the skill set and expectations in a reciprocal fashion.

Year Two Inquiry Courses (Inquiry 2E03 and Cell Biology PBL 2K03)

Two courses frame the Year Two experience. Inquiry 2E03 is coordinated by one of us (S. Nastos) and uses different instructors annually. Students work in groups of ten over the course of thirteen weeks on a problem statement that encourages discovery of concepts in Biochemistry. They meet with an expert facilitator every two weeks for forty-five minutes and discuss direction and their reflective journals. At the end of the course, one member of each group is called on randomly to present the group findings, for thirty minutes to the entire class (160 students). This is followed by thirty minutes of questions from the audience and all group members may answer. Self and peer evaluation are integrated into the activities and are used in assessments.

Cell Biology is modeled as an inquiry course. One of us (D. Harnish) coordinates the course and works with instructors who have been new initiates in each year (practice transfer). There are two components. Thirty-six groups of five students are provided with a problem statement that will encourage exploration and formal linkage to cell biology concepts, which are explored in tutorials and facilitated with teaching assistants. Groups occasionally meet with the instructors as they identify a need and formally meet with instructors for a videotaped discussion of the problem at the course midpoint and at the end of the course. Students review videotapes and evaluate their learning. They then meet, as a large group, for two hours with a knowledge expert, whom they question. This allows them to explore the dimensions of expertise and always validates, for them, their learning. The tutorials focus on what might traditionally be seen as textbook cell biology. We have tried different ways of doing this and have settled on the following learning activities in contrast to simple assignment of chapters. Students meet as a large group in week one (180 students). They are provided with one figure from the textbook (hemopoiesis) and in lecture and in groups, generate questions that they might have. These are sorted by the TAs who then help students find answers using an inquiry approach. When they have more knowledge we meet to repeat the exercise because their questions are now more sophisticated. This builds a knowledge bank that addresses all the major concepts, in a non-linear way. Students write weekly group journals.

Year Three Inquiry Courses

First-term Inquiry has 10 sections and groups of 20-25 students self-select into areas of interest. Three of us have facilitated with some of these groups or work with others to ensure integration of Year One practices. M. Jordana co-developed an Inquiry section that has students acting as expert reviewers and grant panel members with real grants written by immunology faculty members. C. deLottinville facilitates two sections of 25 students who focus on communication skills. D. Harnish developed a section with viral vaccines. In all cases the students work in groups, informed by the methodologies for evaluation and the pedagogical approaches in Year One, including videotaped oral discussions as examinations of knowledge.

Inquiry 3H03 was designed by Year One instructors. Students can complete this course as

individuals or in groups and have the flexibility to complete it at any time after Year Two anywhere in the world. Students set their learning objectives in the context of a personal identification of knowledge needs and skill needs and develop an evaluation scheme that is agreed upon with supervisors. A rich menu of evaluation is utilized including self and peer evaluation, reflective journals and scholarly writing. At this stage, students need appreciable self-directed learning skills to do well in this course.

Year Four Courses

As students have advanced through the programme, they have identified specific learning objectives that were not being met in previous courses or did not exist as courses at McMaster. For example, two students expressed an interest in exploring Chaos theory in the context of integrating course material from three Faculties. We have had to respond to this as it has occurred and there are now six new inquiry courses that allow students to set and meet their own learning objectives (knowledge and skills), as identified. Effectively, we have courses that are learning spaces for a wide variety of variable needs. The structures are modeled on the Year Three experience and students can arrange to do this in groups or as individuals. One of these is being used this year by 16 students interested in exploring the dynamics and development of groups with M. Secord. Additionally, we have designed a Year Four course on research initiatives. In this course, students attend any research or scholarly seminars, anywhere on campus and write a formal journal to summarize the content. They must then generate a question and seek an answer (modeled on Psychobiology). Students do this in pairs or larger groups, evaluate each others' work and submit their two best journals, of six per term, for formal evaluation. They also personalize their own evaluation scheme in the context of their learning objectives. This is coordinated by one of us (D. Harnish).

Four years ago we initiated a course, HTH SCI 4X03, Peer Tutoring and Collaboration. The intent was that students would engage and reflect on a variety of activities that might include peer tutoring in local secondary schools, musician visits to hospital wards, buddy systems for students in the programme, peer tutoring of university students, peer tutoring in ESL programmes and many others under faculty supervision (M. Secord). The activities would occur in each of the four years of the programme but students would register in the course and receive formal credit, only in Year Four of their studies. It has encouraged very rich activities and formally recognizes students for elements of learning that do not fit into a lecture. It also gives students a much stronger sense of community and informs their formal studies in various ways. Early each year of the programme students submit a form that asks them to define specific learning objectives and goals or skills in this context. They then describe how they intend to engage themselves in activities that will help them achieve the goal. Year One students receive feedback on goals from their Inquiry course instructors. Year Two and Three students receive feedback from Year Three and Four students, respectively, using a specific rubric. Year Four students receive feedback from a course facilitator (S. Park, M. Secord, D. Harnish). At the end of each year, students submit a form that describes their experience and they then evaluate whether they were able to achieve their goals and to what extent they did so. Year Four students discuss all four years of the experience during an individual exit interview. Success of this initiative is dependent on the framework of skills identified in Year One and reinforced each year. Students refine the course each year.

The Role of Technology

In 1995, we implemented FirstClass (Centrinity) as LearnLink at McMaster University but with a specific pedagogical overlay that allowed representation as a 'Little Red Schoolhouse'. We treat this as an open system in that students can enter courses or learning spaces whether they are registered or not, across 400 courses, in four Faculties at all levels. It allows for continuous flow education as a concept and practice, gives students public and private spaces and supports the BHSc Programme as a learning community. Alumni retain access. The system promotes deep, not surface learning (Carl Cuneo and Del Harnish, manuscript in preparation). For more information, please contact D. Harnish or visit http://www.learnlink.mcmaster.ca/. When we write reference letters for students we can search individually across four levels for all course submissions, peer and self evaluation forms and group experiences. Students also have this record for reflection. This acts as a record of learning and as a way of measuring development, with time, in the context of skills.

Evidence of Success

We offer evidence of success for your consideration and in the context of the original objectives. The evidence takes several forms and we will provide these in order, moving from entrance to programme exit. We will try and indicate the level of confidence we have in each element.

It is difficult to interpret evidence in the context of increases in the number of students applying to the programme. We might expect that the way students describe their experience to secondary school students would increase applications. Applications to the programme have increased each year with a bulge in the double cohort year. We also agreed to admit more students in the context of double cohort issues and student success (Table 4).

TABLE 4. Bachelor of Health Sciences (Honours) Programme Admissions Statistics.

Year	2000	2001	2002	2003	2004
Applicants	800	1800	2300	3250	2600
Class Size Target	80	80	80	160	160

Although, we attempt to moderate admissions based solely on marks by rating a written supplementary application, Level I class averages are consistently above 93%. Applicants, who by definition could attend any post-secondary institution, choose this programme. Overall, acceptance rates from secondary school are approximately 50%, which is approximately twice the take-up rate of other faculties at McMaster. We also know that students automatically receive an offer from science if they do not receive an offer from us but acceptances of the science offer are low (30% of normal science rates) in the absence of an offer from us.

We conduct teaching evaluations, both formative and summative. The instructors in this nomination are, on average, more effective than instructors in other BHSc courses, and students feel they learn much more in these courses (Appendix 1, Table 1 and 2). At the end of Year One, for the current format, we asked students to rate various opportunities in their learning experience on a seven point likert scale where '1' is not at all helpful '4' is fairly helpful and '7 'is very helpful

(Appendix 2). The trend is for medians and means of 6 for discussions of giving and receiving constructive feedback (Figure 1), self-evaluation (Figure 2), group evaluations (Figure 3), final skills reviews (Figure 4), opportunities for teaching others (Figure 5), opportunities for learning from others (Figure 6), opportunities to improve time management (Figure 7), opportunities to improve critical thinking skills (Figure 8), and the overall experience (Figure 9). We also asked about various other dimensions and activities, including: Peer Tutors, personal interviews, group work and communication skills. Again these elements were rated uniformly high (Appendix 2, Figures 10-18). Of particular importance was the clear message that students wanted more courses taught this way, the course helped with other courses they were taking and will help both with future courses and a career (Appendix 2, Figures 19-22).

It is difficult to assess student learning by traditional measures such as marks and we do not believe we can reliably use this data. Grayson (1999) has stated that there is a correlation between secondary school marks and university marks. Given the high programme entry marks of BHSc students, we would expect a strong relationship to their university grades. The mean and median marks in Year One inquiry are A with a range of B to A+. It is perhaps significant that the mean/ median is A and not A+ with this group of students. The mark is negotiated with the facilitator, based on evidence but students must self-evaluate before this interview. They do not all want an A+. Their self evaluation skills have clearly developed in many ways. Ninety percent of students are correct on their first assessment of grade (no negotiation needed). In the Faculty of Science, mean and median marks in a Year One inquiry course are about the same but the entering average of students is lower. Students from the BHSc Programme have median marks of A- to A in science courses where the course median is C+ to B- (Biologies, Chemistries, 400-1200 students). In Anatomy and Physiology, 180 BHSc students take the course with 400 Nursing students (OAC = 80% or higher). The group medians are 62% for nurses and 83% for BHSc students. These course medians have been consistent over four years and we would not expect to see an increase in BHSc marks as a measure of learning, in the same way it might occur in other contexts.

One of us (K. Trim) is completing her dissertation and her work, with our participation has been instrumental in a scholarly examination of student learning. This is perhaps the most objective and convincing data (Appendix 3, Tables 1 and 2). BHSc students' skills development (n ~ 100 students per year) were measured in three consecutive years on three scales examining their inquiry skills improvement in Year One of their studies. These skills included: critical thinking skills (i.e., appraisal of arguments, library search strategies, and self-assessment skills) (Facione and Facione, 1996); self-confidence to approach new academic tasks (Inquiry Task Self-Confidence and Academic Goal Completion Self-Confidence scales) (Bandura et al., 1986; Betz et al, 1996; Trim 2005); and their Approaches to Studying (meaning and reproducing orientation scales) (Ramsden, 1983). In addition, BHSc students (n = 106) were re-surveyed in their upper years on the same measurement scales and their scores were compared to upper year students who had not taken a first inquiry course (i.e., non-inquiry students, n = 52) to determine if there was a lasting impact on their academic skills. All scores have a maximum value of 100. Effect sizes were calculated by dividing the difference between the two mean scores by the standard deviation of the mean control score (i.e., either entry or non-inquiry score). According to Cohen (1992), small effect sizes are negative or positive values between 0.20 and 0.49, medium effect sizes are negative or positive values between 0.50 to 0.79 and large effect sizes are negative or positive values above

0.80.

The average mean difference for all scores showed improvement in all measures. For the critical thinking skills: the appraisal of arguments average mean difference was 6.6% (Average Effect Size = 0.40); the library search strategy average mean difference was 13.2% (Average Effect Size = 0.69); the self-assessment average mean difference was 4.7% (Average Effect Size = 0.33). For the self-confidence to approach new academic tasks: Inquiry Task Self-Confidence scale average mean difference was 10.4% (Average Effect Size = 1.22); and, the Academic Goal Completion Self-Confidence scale average mean difference was 5.35% (Average Effect Size = 0.38). For the approaches to learning preferences: the meaning orientation preference average mean difference was 2.4% (Average Effect Size = 0.25); and the reproducing orientation average mean difference was -2.1% (Average Effect Size = -0.21). These small to large positive effect size results are fairly robust in that they represent a large sample of students being compared at the beginning and end of their first year inquiry course, and these results are averaged over multiple years using multiple instructors. In addition, these effect sizes are consistent with the positive benefits on student academic learning reported in the literature (Trim, 2005).

In terms of the comparisons between upper year BHSc students and the upper year students who did not take a first year inquiry course, the critical thinking skills: the appraisal of arguments average mean difference was 8.3% (Average Effect Size = 0.65); the library search strategy average mean difference was 20.5% (Average Effect Size = 1.36); the self-assessment average mean difference was 3.2% (Average Effect Size = 0.90). For the self-confidence to approach new academic tasks: Inquiry Task Self-Confidence scale average mean difference was 6.9% (Average Effect Size = 0.90); and, the Academic Goal Completion Self-Confidence scale average mean difference was 7.2% (Average Effect Size = 0.65). For the approaches to learning preferences: the meaning orientation preference average mean difference was -8.0% (Average Effect Size = -1.25); and the reproducing orientation average mean difference was -14.5% (Average Effect Size = -3.05).

While the first two measures show that the BHSc students have retained their gains reported from the first year of the inquiry course, the large negative effect size on the preference for meaning orientation is perplexing. While it is clear that the BHSc students derive enormous benefit from the repeated opportunities to develop their inquiry skills in all years of their program as evidenced by their 83.3% score on meaning orientation, it may be that they do not experience the extreme competition that the non-inquiry students experience. According to Knapper (2004), high scores on both meaning and reproducing orientation preferences are indicative of students who have a strategic learning orientation in that they have learned to adapt their learning preferences to their environment instead of following their own core learning preferences. BHSc students, with the ample opportunities to engage in self-directed learning with topics that are of interest to them, may have developed core learning preferences. Perhaps this is what we want as an outcome.

There is evidence of a culture of learning that involves faculty members and students. Students speak highly of BHSc Inquiry and its impact. We have received over 150 letters and a sampling of comments, grouped by theme is provided in Appendix 4 (pages vii-ix). We value this evidence and although we have tried to use the perspective of students who have graduated, we

are aware that students might always feel at risk, even after they graduate. Their views might be colored by a future need for references. This is also true for teaching assistants. Jagger Smith's unprompted letter is instructive perhaps (Appendix 5).

Students have created a culture of teaching and learning around the Peer Tutoring and Collaboration course (4X03). This course, conceived by all of us, was designed by the students in the programme (probably an educational first) and has been instrumental in providing opportunities for students to act as facilitators, to further develop inquiry skills, to promote the development of these skills in others and to help each other with university both formally and informally (informal learning) (Appendix 6). Students who peer tutor with Year One students, in Inquiry and Psychobiology, often do so in this context. Students have developed several unique elements of 4X03 that enjoy broad participation, both within and outside the McMaster community. Of special note, students started their own scholarly journal, The Meducator (http://www.meducator.org/). It is a tribute to their engagement on knowledge issues and their ability to use and grow the skills that are developed. The journal is distributed in print and electronic form.

Our students have been successful after four years. Two years of graduation data reveals that 60% of the students attend medical schools, 14% go to law school and the rest distribute to 'Primary Research', Rehabilitation Sciences, Clinical Psychology, Pharmacy, Midwifery, Chiropractics, Naturopathy, Speech Language Pathology and Travel. This later group is the one we envy. We would hope that they become better practitioners and we have evidence that they should, based on success within the skill set. For many of these programmes entrance is dependent on assessment of a record of learning, not just marks. If applicants are selected for interview based on various combinations of qualitative (essays) and quantitative tools (GPA, MCAT), then entrance is dependent on personal qualities and communication skills (McMaster University Medical Admissions Committee).

Global Impact

Gerry Wright, Chair of Biochemistry and Biomedical Sciences states that his learning from this group and the programme students in the context of inquiry has "unequivocally been the high water mark in my 11 years here at McMaster as an undergraduate educator" and that "this has served as a great role model of undergraduate programming in my department and we are now developing a new course using this format" (Appendix 7). One of us (C. deLottinville) is now working with the Medical School to use the inquiry model for Clerkships and to develop the communication skills curriculum. The University of Calgary has now developed a BHSc Programme with inquiry courses as a central theme. We have met with visitors from the University of Calgary, the University of Mexico, the University of Ottawa and were invited to help the University of Ontario Institute of Technology develop a programme. (Evidence available by request.)

The facilitators have held numerous one-day retreats and have met once per week at 7:30 am for over four years. We have also included a list of Conferences and Workshops to which the group has contributed (Appendix 8), including a compendium of inquiry materials collected by one of us (K. Trim) for distribution at the last STLHE meeting.

Future Directions

We started this essay with a reference to a study on critical thinking by Messer and Griggs (1989) in which it was stated that 99% of college students believed in at least one paranormal phenomenon. We conducted a quick survey with our students (n = 125). Eighty-two percent of Year One students believed in at least one paranormal phenomenon. We would argue that it does not matter. If we are teaching through an inquiry perspective then it is more important to offer an interpretation of this data in that context. We would argue that a simple belief is not the issue. If students become skilled in the process of inquiry then they have the means by which to establish beliefs in explicitly scholarly ways. When we handed the survey to the students, the immediate response was to begin discussion in the Inquiry learning space. They did not simply all complete them. The discussion generated questions, always the starting point for seeking answers. We expect that they, like us, would seek answers in the best ways, with evidence, given time. Perhaps this best captures our intent. Perhaps we will ask them again in Year Four or in ten years.

We have been explicit about the need to adapt and adopt the curriculum each and every year and no one thinks it will ever be static. In this context, this group has now replaced a didactic first year biology course with a course that will use inquiry and will have laboratories drawn from all level one courses. This will be a novel experiment, initiated by student concerns and reflections. We are also in the middle of discussions about larger reforms of curriculum, not described in this paper. The intent is to move towards concept based curriculum and away from 3 unit course structures. This may of course mean moving to some version of a 'markless' curriculum but at this point in time these issues are just stimuli for discussion within a group that cares about the entire programme, not just the elements described in this paper.

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Section E: Supporting Documentation

Appendix 1: Overall Course and Instructor Evaluation Data

TABLE 1. INQUIRY COURSE EVALUATION DATA for the amount of learning students felt that they learned in Inquiry compared to other courses at this level and for student's opinion on the overall effectiveness of their Inquiry Facilitator. The results show that students felt they learned more in this course and that students consistently rate Inquiry Facilitators as very good to excellent.

weighted averages n = number of students SD = standard deviation						All Years Mean (SD) All Courses (n = 314)	2003-2004 Mean (SD) 1E06 (n = 171)	2002-2003 Mean (SD) 1EE3 (n = 74)	2001-2002 Mean (SD) 1E03 (n = 73)	2000-2001 Mean (SD) 1EE3 (n = 69)	2000-2001 Mean (SD) 1E03 (n = 69)
Compared to other courses at this level, did you feel you learned:						4.25 (0.85)	4.54 (0.73)	4.21 (0.84)	4.12 (0.83)	4.07 (0.97)	4.07 (0.97)
Much More In This Course	More In This Course	About The Same As Other Courses	Less In This Course	Much Less In This Course							
5	4	3	2	1							
Overall, what is your opinion of the effectiveness of the Inquiry Facilitator in this course:						8.88 (1.42)	8.89 (1.44)	8.67 (1.56)	9.19 (1.15)	8.85 (1.21)	8.75 (1.69)
1	2	3 4	5 6	7 8	9 10						
Very Poor	Poor	Acceptable	Good	Very Good	Excellent						

TABLE 2. BHSC COURSE INSTRUCTOR EVALUATION DATA across different levels in the BHSc (Honours) Programme for 2003-2004. Students, on average, rate BHSc Instructors as very good; however, the data from Table 1 (above) shows that students rate the Inquiry Facilitators as very good to excellent.

weighted averages n = number of courses						Level 1 Courses (n = 3)	Level 2 Courses (n = 6)	Level 3 Courses (n = 9)	Level 4 Courses (n = 15)	All Courses Except 1E06 (Formerly 1E03/1EE3) (n = 33)
Overall, what is your opinion of the effectiveness of the Instructor as a teacher in this course:						7.01	7.30	7.98	8.36	7.46
1	2	3 4	5 6	7 8	9 10					
Very Poor	Poor	Acceptable	Good	Very Good	Excellent					

Appendix 2: Course Evaluation Data

Figures 1 to 18 are course evaluation results for 2003-2004 showing how course activities and components were rated in terms of their helpfulness to student learning in Inquiry 1E06. (Please note: non-responses were excluded from the data set.)

FIGURE 1: Discussions on Giving and Receiving Constructive Feedback
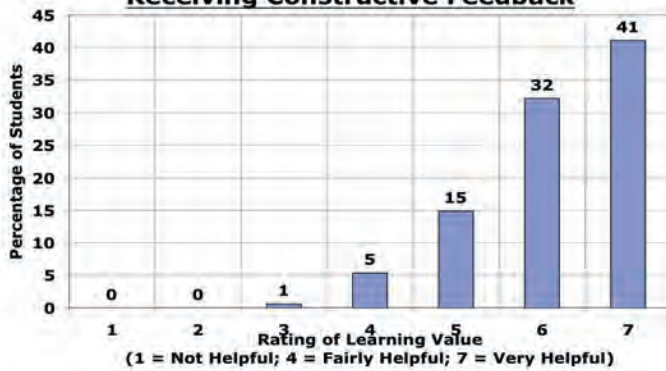
Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	1	5	15	32	41

FIGURE 2: Completing Self-Evaluation Forms

Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	1	1	4	11	22	35	26
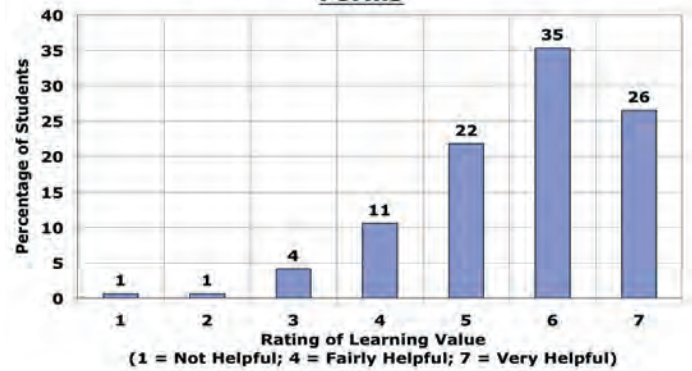
FIGURE 3: Completing Group Evaluation Forms

Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	1	1	5	12	22	34	26
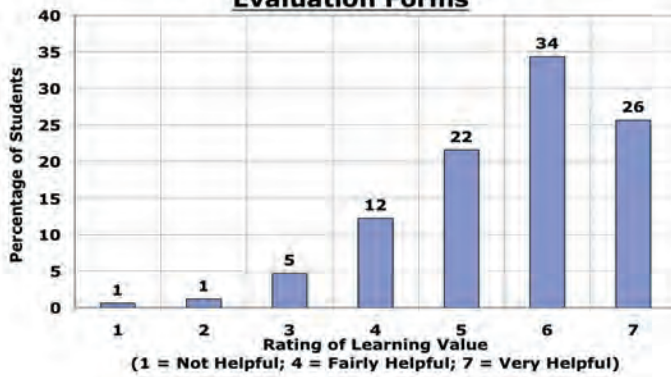
FIGURE 4: Completing Final Skills Review Forms

Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	3	8	14	32	43
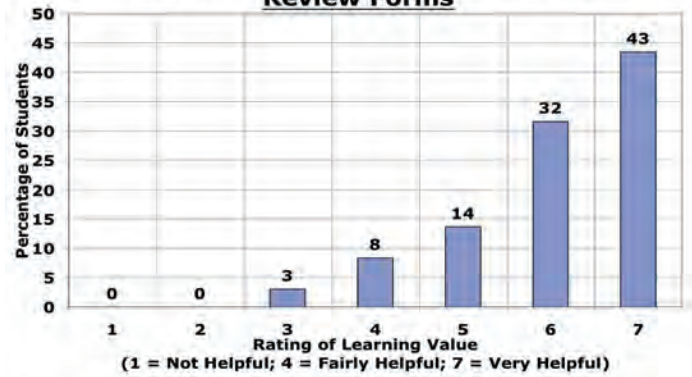
FIGURE 5: Having the Opportunity to Teach Other Members of your Group

Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	1	4	21	33	39
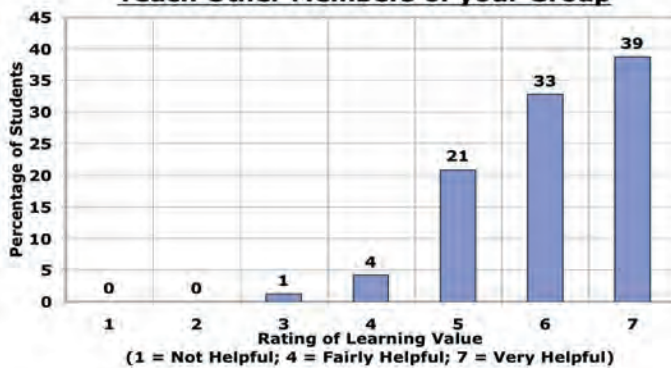
FIGURE 6: Having the Opportunity to Learn from Other Members of your Group

Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	1	3	10	33	51
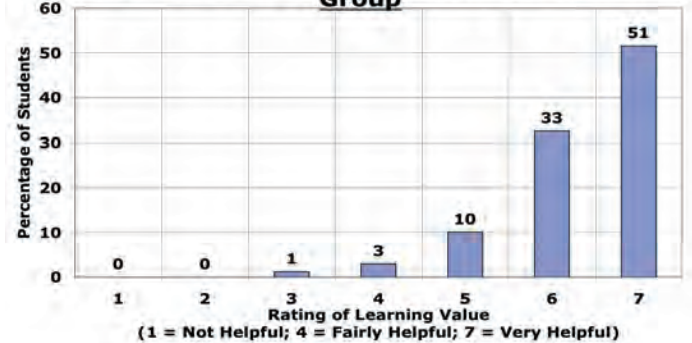
FIGURE 7: Opportunities to Improve my Time Management Skills

Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	1	1	4	9	17	24	41
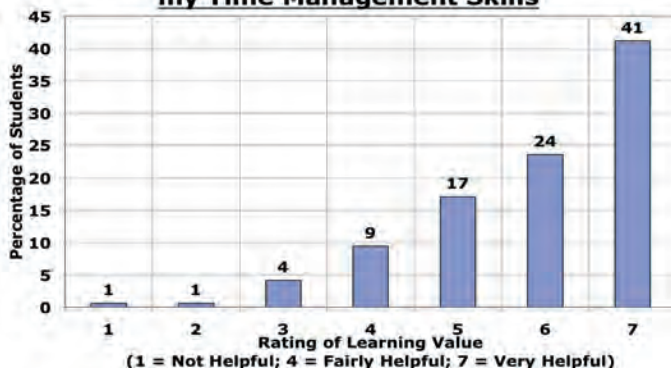
FIGURE 8: Opportunities to Improve my Critical Thinking Skills

Percentage of Students by Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	1	0	4	5	23	66
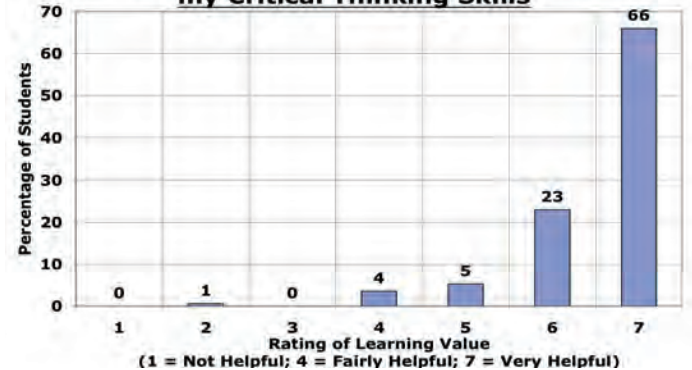
FIGURE 9: Overall, how Helpful was the Course to your Learning?

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	0	2	6	40	52
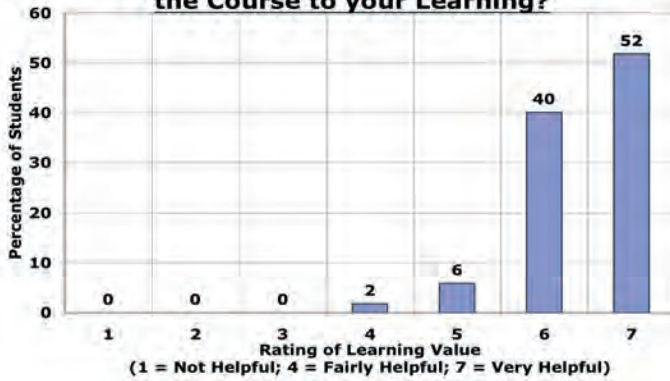
FIGURE 10: Discussions about Communication Skills

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	1	8	20	31	40
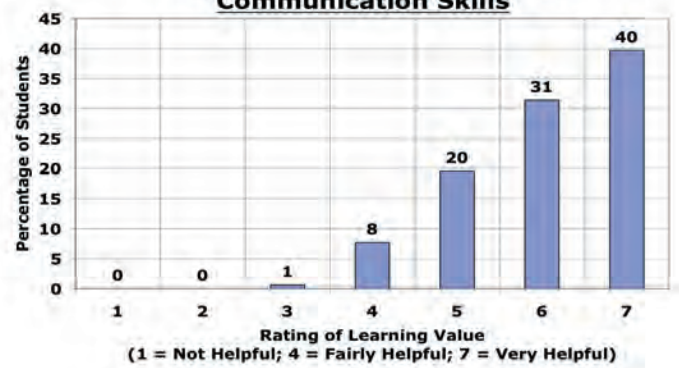
FIGURE 11: The Benchmarking Exercises

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	3	9	22	29	37

FIGURE 12: The Standardized Patient Interviews

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	1	0	1	1	6	22	69
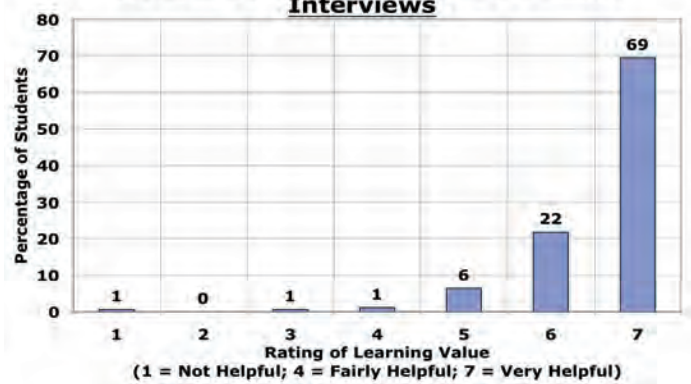
FIGURE 13: The Library Tutorials

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	2	8	8	11	20	27	21
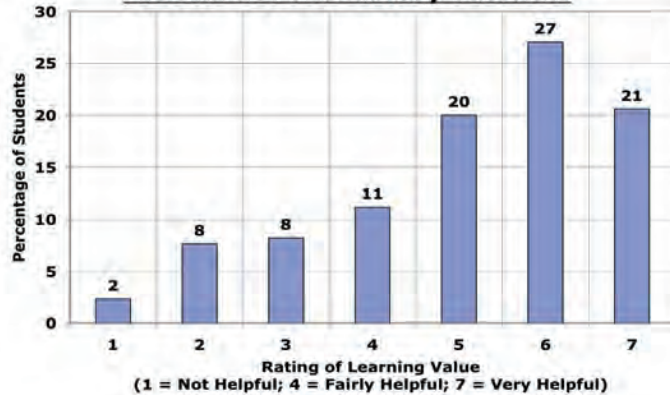
FIGURE 14: Discussions on Evaluating Information/Crap Detection

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	1	2	10	20	28	31
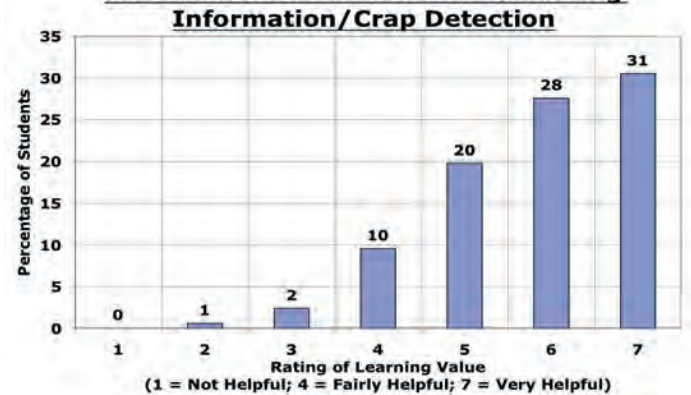
FIGURE 15: Large Group Discussions during Classtime

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	2	14	20	29	35
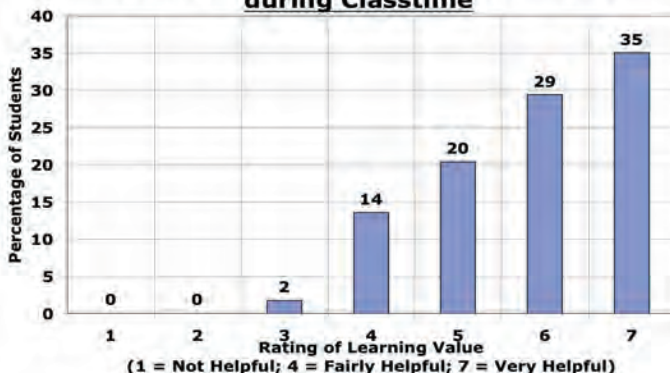
FIGURE 16: Support from the Peer Tutors

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	1	1	11	8	33	47
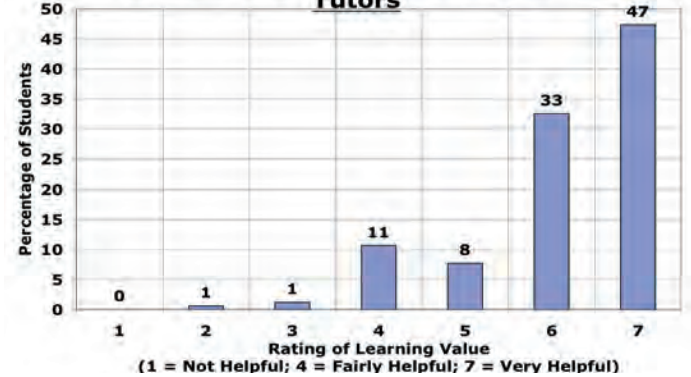
FIGURE 17: Personal Interviews with the Instructors

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

Rating	1	2	3	4	5	6	7
%	0	0	0	2	9	27	61
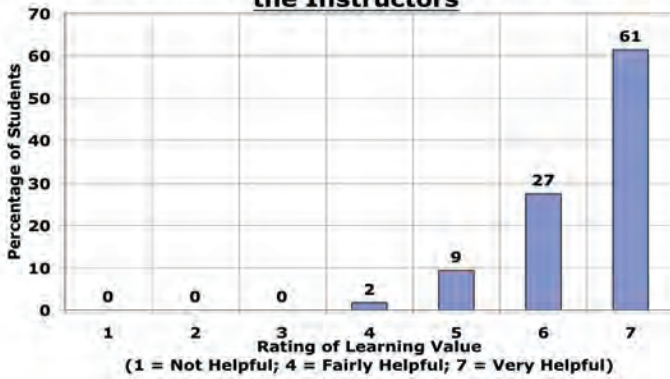
FIGURE 18: Working in a Small-Group and Presenting your Process and Findings

Percentage of Students vs. Rating of Learning Value (1 = Not Helpful; 4 = Fairly Helpful; 7 = Very Helpful)

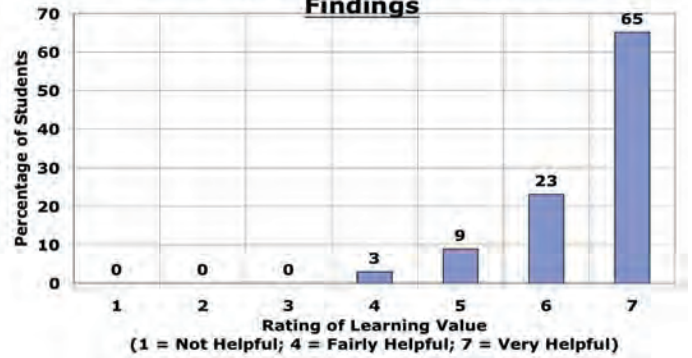| Rating	1	2	3	4	5	6	7
%	0	0	0	3	9	23	65

FIGURE 19: Having experienced BHSc Inquiry, would you want to take another course in the future that had a small-group, problem-based learning component?
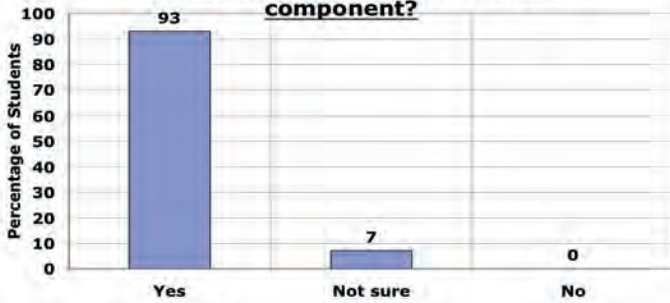
Yes	Not sure	No
93	7	0

FIGURE 20: Do you feel that the skills you learned in this course has helped you with other courses you have taken this year?
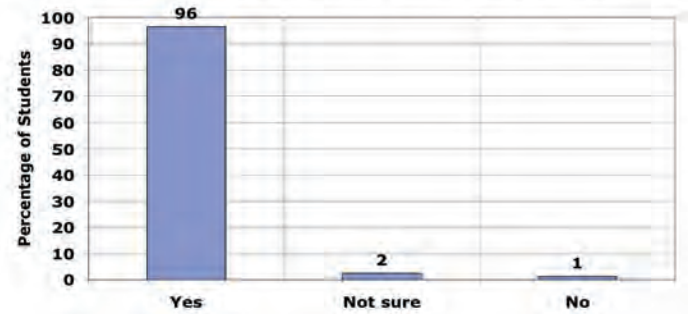
Yes	Not sure	No
96	2	1

FIGURE 21: Do you feel that the skills you have learned in this course will help you with university courses you may take in the future?
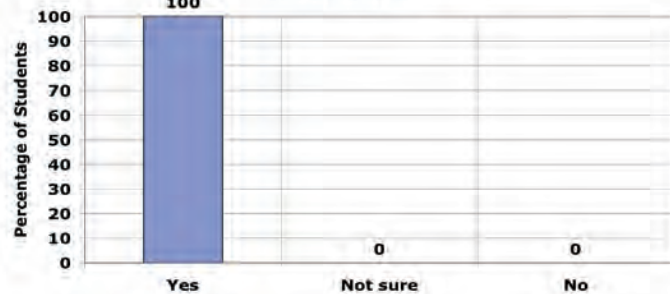
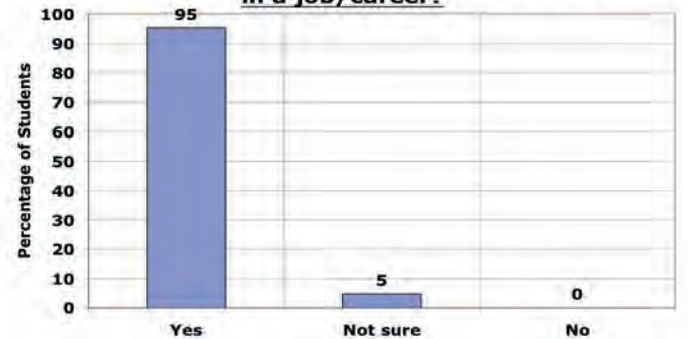| Yes	Not sure	No
100	0	0

FIGURE 22: Do you feel that the skills you have learned in this course will help you in a job/career?

Yes	Not sure	No
95	5	0

iv

Appendix 3: Year One Entry/Exit Changes in Student Skills and Programme Entry/Exit Changes in Student Skills

TABLE 1: AT THE END OF LEVEL I, Summary of Comparisons of Bachelor of Health Science Students Scores on Critical Thinking, Student Confidence and Approach to Studying Inquiry Skills Development.

		First Year Inquiry Students 2000-2001	First Year Inquiry Students 2001-2002	First Year Inquiry Students 2002-2003
Critical Thinking Skills (Mean Scores and Effect Size)				
Appraisal of Arguments	Entry	**69.5**	61.9	66.6
	Exit	**80.3**	67.1	70.3
	Effect Size	**0.76**	0.19	0.26
Library Search Strategy	Entry	**67.1**	70.1	**77.2**
	Exit	**85.9**	79.7	**88.3**
	Effect Size	**1.13**	0.27	**0.68**
Self-Assessment	Entry	**74.6**	67.9	**69.9**
	Exit	**81.2**	70.3	**75.0**
	Effect Size	**0.57**	0.08	**0.33**
Student Confidence to Approach Inquiry Skills Development (Mean Scores and Effect Size)				
Inquiry Task Self-Confidence	Entry	Not Available	**71.3**	**73.3**
	Exit		**82.6**	**82.7**
	Effect Size		**1.23**	**1.22**
Future Academic Goal Self-Confidence	Entry	Not Available	**70.4**	76.1
	Exit		**76.3**	80.9
	Effect Size		**0.42**	0.33
Student Approaches To Learning (Mean Scores and Effect Size)				
Meaning Orientation (Deep Learning)	Entry	Not Available	**74.7**	80.3
	Exit		**79.4**	80.9
	Effect Size		**0.34**	0.17
Reproducing Orientation (Surface Learning)	Entry	Not Available	**67.0**	68.1
	Exit		**63.8**	67.1
	Effect Size		**-0.33**	-0.09

1. All sub-scores totalling 100: Therefore, mean differences on scores were also considered to be percentage of difference between scores.
2. Effect Sizes calculated by dividing the difference between the two scores (e.g. difference between entry and exit scores on the same students) and dividing these scores by the standard deviation of the entry score.
3. To adjust for multiple inferential tests, the p-value was divided by the number of tests per year for each sub-score. Therefore, the critical value for p is 0.017 in this instance. Significant p-values are in **bolded print.**

TABLE 2: AFTER FOUR YEARS IN THE BHSC PROGRAMME, Follow-up Comparisons between Upper Year BHSc Students and Upper Year Science Students who did not take a First Year Inquiry Course on Critical Thinking, Student Confidence and Approach to Studying Inquiry Skills Development.

Critical Thinking Skills (Mean Scores and Effect Size)		
Appraisal of Arguments	Non-Inquiry	**74.7**
	BHSc	**83.1**
	Effect Size	**0.65**
Library Search Strategy	Non-Inquiry	**63.2**
	BHSc	**83.7**
	Effect Size	**1.36**
Self Assessment	Non-Inquiry	**64.8**
	BHSc	**78.0**
	Effect Size	**0.90**
Student Confidence to Approach Inquiry Skills Development (Mean Scores and Effect Size)		
Inquiry Task Self-Confidence	Non-Inquiry	**78.7**
	BHSc	**85.6**
	Effect Size	**0.90**
Future Academic Goal Self-Confidence	Non-Inquiry	**76.7**
	BHSc	**83.9**
	Effect Size	**0.65**
Student Approaches To Learning (Mean Scores and Effect Size)		
Meaning Orientation (Deep Learning)	Non-Inquiry	**91.3**
	BHSc	**83.3**
	Effect Size	**-1.25**
Reproducing Orientation (Surface Learning)	Non-Inquiry	**85.0**
	BHSc	**60.5**
	Effect Size	**-3.05**

1. All sub-scores totalling 100: Therefore, mean differences on scores were also considered to be percentage of difference between scores.
2. Effect Sizes calculated by dividing the difference between the two scores (e.g. difference between BHSc and Non-Inquiry scores) and dividing these scores by the standard deviation of the Non-Inquiry score.
3. To adjust for multiple inferential tests, the p-value was divided by the number of tests per year for each sub-score. Therefore, the critical value for p is 0.017 in this instance. Significant p-values are in **bolded print.**

Appendix 4: From Students - Letters of Support

Theme: Skill Development and Lifelong Learning

"I don't think I have ever learned so many skills that I can be as proud of, especially as a first year student. I am glad that I know how to think for myself when I read information and make decisions about the validity of an answer presented to me. I take pride in the fact that I have constructed knowledge. I am proud of my ability to research and find answers to complex questions. I am satisfied with what I have learned through my health sciences courses, especially Psychobiology and Inquiry regardless of the mark I received. I have always been proud of the marks I've gotten throughout my educational career, but I can't describe the satisfaction and pride that I feel today for this new set of skills I possess. Unlike traditional learning, where I was given information and answers to learn, here I was challenged to find those answers on my own and to have faith in my best thinking. That does not mean that I was always right, but right answers weren't always the point. My ideas were the point. Thinking for me was the point. Learning from others was the point." *(Sarah Sinasac, BHSc Graduate)*

"Our facilitators… provide guidance not by telling us what to do or what to know. Rather, they engage in dialogue with us, through formal and informal conversations, to help us realize and understand our individual processes of learning." (*Eileen Estrabillo, BHSc Graduate*)

"[Inquiry] has armed me with a multitude of learning skills that have helped me to succeed in courses inside and outside the Faculty of Health Sciences and in positions of employment. These skills include, but are not limited to: developing and refining a research question, identifying resources, evaluating and integrating information, collaborating with others and self-reflecting upon strengths and weaknesses." (*Kristy Armstrong, BHSc Graduate*)

"The knowledge I am using as a fourth year student doing a thesis is not of specific topics (indeed this knowledge is important in some cases) but of problem solving, critical thinking and skills for working in groups… It is these skills that allow me to understand and analyze the content needed for a quality academic analysis of an issue. The Inquiry facilitators in BHSc have been the most integral part my acquisition of these skills." (*Michael Wilson, BHSc Graduate*)

"I can say from experience that this program does not emphasize knowledge acquisition through text, but through experience, exposure and moreover through inquiry…Through their hard work and commitment to learning these facilitators have not only given me the tools to be a lifelong learner but have also inspired me to pass on these skills as an educational leader in the future." (*Rikin Patel, BHSc Graduate*)

"I reacted strongly and negatively to the inquiry experience. I hated the class because of it lacked both structure and clear requirements, in order for me to know exactly what I needed to do to achieve the mark I desired… Over the past four years, this perspective has changed drastically. I took inquiry classes in second and third year, and had the privilege of being a peer tutor for a first year BHSc inquiry class in this past fall. As I watched these first years struggle with challenging their definition of learning, I began to realize the influence that this class has had on my learning and my life more generally… These facilitators are doing more than just teaching a class, they are encouraging a way of life which challenges boundaries, promotes individuality, and breaks down barriers of institutions and convenience. *" (Liza McConnell, BHSc Graduate)*

Theme: Small Group & PBL Learning Environments

"I learned through the intimate interaction I had with my inquiry… Only these teachers take the time to meet students individually and understand the diverse number of topics in a given class. Only through their

commitment to my education were they able to challenge me to think, teach me to back my comments with evidence, and inspire me to continue to improve after the course was over." (*Phedias Diamandis, BHSc Graduate*)

"[This] is a unique, dynamic and interactive style of learning that allows faculty members and students to act both as teachers and learners. As opposed to just presenting large amounts of information, which is committed to memory and then quickly forgotten following an exam, [the inquiry facilitators] provide a structure and process in which true learning, rather then simply pure memorization and regurgitation, can take place." (*Caroline Chua, BHSc Year IV*)

"The inquiry facilitators made it possible to feel comfortable in such a novel environment. Instead of treating us like a number, my inquiry facilitator took an interest in each and every student, allowing for comfortable interaction between teacher and student." (*Lauren Kopenchanski, BHSc Year IV*)

"From a humanities perspective, both facilitators that I worked with encouraged me to look beyond the science and look at the underlying issues or the consequences of the issue we studied. In one full-year course, we were given an introduction to the study of biology and virology, as well as history, geography and the social sciences." *(Hugh Boyd, BHSc Graduate)*

Theme: Individual Development
"The most significant outcome of the course for me was the confidence I developed. My first year of university left me doubting my abilities. Inquiry, allowed me to recognize my strengths while simultaneously providing me with the opportunities to improve upon my weaknesses and to continue challenging myself." (*Amandev Aulakh, BHSc Graduate*)

"Inquiry has allowed me to evolve into an individual who is able to 'think outside the box"; a person who will strive to continually challenge and change inherent practices for a common good. Consequently, inquiry has provided me with skills that can and will be used, not only in my academic career, but also throughout my lifelong development." (*Ana Ganhao, BHSc Graduate*)

"We were encouraged to explore academics without boundaries, and with the enthusiasm necessary for limitless possibilities. This has allowed me to widen my perception of where I would like to be in the future, considering options I may not have realized existed… They have provided an outlet for growth as both a person and a scholar." *(Jason Corcoran-Barre, BHSc Graduate)*

Theme: Self-directed Approach to Learning
"A major struggle for many people, including myself, was to take responsibility for our own learning, rather than attempting to meet the criteria set by those who are in control of our marks. The facilitators really taught me that, almost always, setting my own learning objectives would result in a much more profound understanding of the topic at hand. Furthermore, an emphasis was placed on the ways that the skills we learned in the class would translate into future endeavors." (*Dilan T. Dissanayake, BHSc Graduate*)

"The inquiry classroom is a place where students can focus solely on developing the skills that we lack in the context of accomplishing a given task. This safe environment allows growth, without the additional pressures associated with tests and labs. However, the opportunity granted by the Inquiry course would be sorely incomplete without highly trained facilitators, who invest time and effort in the fostering of these skill sets." (*Guillaume Poliquin, BHSc Graduate*)

Theme: The Facilitators

"Often times we come across an individual, or even a group of individuals, whose extraordinary teaching ability brings out the very best among us, as students, and as people of a society. For me, and many others, these people have been the facilitators of our inquiry classes in first year." (*Abhishek Raut BHSc Year III*)

"Not only did our inquiry professors make time to meet us regularly on an individual and group basis, but they also took the time to meet with each other, to discuss how they could guide us better, and went to literature to find the best ways to teach us. They were willing to spend the extra time that the inquiry model requires of a facilitator as opposed to subject-based teaching, just so that they could help us progress as much as possible…There is an obvious and exceptional dedication the inquiry facilitators have towards our success and learning." (*Navneet Singh BHSc Year III*)

"I found that my inquiry facilitator invested a great deal of time and care into the relationships that she developed with her students. My facilitator went to great lengths to create a supportive atmosphere for us, so that we would feel comfortable taking risks and worked further to make important learning opportunities accessible to all students in the programme." (*Shail Rawal, BHSc Graduate*)

"The facilitators provide guidance to help students utilize the skills that are so crucial to research, as well in everyday life, in a manner that is not condescending or too directive. They help students communicate ideas and find approaches to problem solving that the students already have within. Our Inquiry facilitators are very approachable and willing to compromise their time so that maximum learning can be accomplished among their students. They meet in the early morning once a week, to discuss issues concerning their students, in order to deal effectively with certain problems and/or to report ideas and observations. It is evident that our facilitators work together in order to optimize their teaching and to ensure that their students are well guided." (*Thy Dinh, BHSc Graduate*)

"When I entered into my first inquiry class I was greeted by an amazing woman who, unknown to me, would have a largely significant impact on my life. I was catapulted into an entire new style of thinking and learning and was able to refine my creative thinking skills and use these skills in all of my classes to produce work that was way above that which I thought I could ever create." (*Daina Nestick, BHSc Graduate*)

"I would change nothing about my experience in inquiry of the last three years… I feel that I have learned the most from PBL courses, especially those offered as inquiry. My ability to retain information in this environment, in a conceptual manner promoting discussion and understanding, is unsurpassed in nature. In terms of my personal abilities which influence my identity, such skills as those in organization, communication, critical evaluation and research, I strongly believe that they have manifested themselves in my other endeavors here at McMaster and were developed in large part to those dedicated individuals who put themselves second to their students." (*Joseph D. Zakaria, BHSc Graduate*)

Appendix 5: Letter of Support from Jagger Smith, BHSc Graduate

Del,

You can tell anyone that still thinks BHSc is not providing them with the skills they need to get a job that they're dead wrong. I followed my girlfriend to Cochrane Ontario, a town one hundred kilometers north of Timmins with a population of five thousand and very few job prospects for young educated people. The first lesson I learned here was that my degree meant squat. When I told people I had graduated from university they either thought I was too educated to work for them or worried that I didn't have any experience. Nobody in town cared that I got straight A's in fourth year. In Cochrane a university degree carried very little social capital and was more often than not, a liability. However, today I was offered a $30

000/year job in hospital administration at the Lady Minto Hospital in town. They have designed this job around me and have assigned me ambitious projects that offer significant and marketable experience. This kind of thing doesn't happen to people up here, most don't get jobs never-mind jobs in their field. I am very lucky but most importantly I had more than a university degree, I had life training.

The best lessons I got out of BHSc so far have centered around how to design my own project and how to recruit supervisors for 3H03 and the thesis. I treated looking for work the same way I handled these projects. From these experiences I had learned how to make connections with important strangers and sell myself as someone they wanted to work with and I re-used those same skills. It was amazing. I took language right out of IREC and wrote keywords into my cover letter (I've attached it for you to see). Then, I marched down to the hospital and talked to the human resources director, she wasn't too helpful but guided me to the CEO's assistant who was really helpful. She was blown away with my resume, astonished at my initiative and loved my writing. (I'm only tooting my own horn because I was so surprised at her response - I thought everyone knew how to do this stuff.) Having used my research skills I knew that as a recent graduate I was eligible for outside funding. I met with the CEO and sold him on putting something together for me. We worked out a plan around what I was interested in and what I wanted to do then we wrote the funding application. All of this happened within 6 weeks of my moving to a town where I knew no-one. Since then we have been waiting for funding approval which just came through today.

Del I am so proud of myself today and I'm so indebted to everyone in the programme for all the little life skills they have given me. The abilities of a teacher are measured by the success of their students and you guys nailed it. Please take my story and use it as evidence of your accomplishments and as encouragement for everyone involved in BHSc.

In gratitude,
Jagger Smith

Appendix 6: Peer Tutoring and Collaboration 4X03

The following section shows supporting evidence from Health Sciences 4X03 that the BHSc students have developed considerable self-directed learning and self-evaluation skills.

<u>Examples of Collaboration in the McMaster Community</u>
1. **Quality in Education Project** - A student (S. Park) formed a stakeholder group of faculty, staff, students, administrators and industry to examine best practice in education and subsequently developed a framework for assessing quality in education at McMaster University.
2. **Peer tutoring** – Several third and fourth year BHSc students are involved in peer tutoring first year Science inquiry (Inquiry 1SC3).
3. **Research assistantships** – Many of our students spend their summers working or volunteering in research positions, from as early as first year. Some continue to work during the school year.
4. **J Constant** – Several students formed a musical band, played at multiple events, and produced a CD. The proceeds from the sale of the CD went to the McMaster Children's Hospital for the Mother's Day Telethon.
5. **Montreal Maniacs** – Several students organized a cycling trip to Montreal. The proceeds from the money raised also went to the McMaster Children's Hospital. They followed the Montreal trip up with one to BC. They were featured on *CH News*.
6. **MACylce Coop** – Some students organized a bicycle repair shop on campus to promote a 'greener' environment.
7. **The Meducator** – Scholarly writing on medical research and health ethics. Published twice per year, this shows that students used their inquiry skills.
8. **Emergency First Response Team** – Many of our students are involved in EFRT, which responds to

emergencies on campus.

Examples of Collaboration in the BHSc Community

1. **Self-organized study groups** – The students recognize the value of collaboration (e.g. 'Chem Madness' biweekly sessions for Chemistry 1A03/1AA3).
2. **Course evaluations and debriefing sessions** – Almost all students fill out summative and formative course evaluations, and most attend debriefing sessions with the BHSc Administration, and reflect on the importance of feedback for courses, and that it yields change.
3. **Welcome Week** – The BHSc students put a lot of planning and effort into welcoming the new students into the programme, and fostering a collaborative community from the start.
4. **BHSc Society** – The student society is heavily involved in the BHSc, McMaster and surrounding communities (e.g. coffee houses, choir, formals, sport teams, etc).
5. **Peer tutoring** – Approximately half of the current fourth year BHSc students are involved in peer tutoring first year BHSc inquiry.
6. **First year/Fourth year Information Night** – Peer tutors organized an evening inviting all programme students to attend a session regarding career options, course selection etc.

Examples of Collaboration in the Surrounding Community

1. **Volunteering** – Almost all of our students volunteer in the community, be it a hospital, geriatric nursing home, Big Brothers/Sisters, etc. They have developed a self-evaluation and reflection form to share their experiences on Learnlink, modelling inquiry.
2. **International health initiatives** – Many of our students travel and volunteer aboard, and are involved in various projects.
3. **International Women's Day conference** – Two of our students were organizers for the women's conference on campus recently.
4. **Bathtub Project** – Two of our students organized a very successful project for Violence Against Women Awareness week. The project involved gathering toiletries for battered women in shelters. This project was featured on *CH News*.
5. **Peer tutoring** – Approximately 75 BHSc students volunteer as peer tutors in the Hamilton school system. This outreach program was planned by the students, with the guidance of a year one inquiry facilitator, who is involved in special education. They have a choice an inner city elementary and middle schools with need for ESL support, several high schools with struggling students, and a unique Hamilton high school with 'self-paced learning'.
6. **Math Enrichment Day** – This was an event organized by the BHSc students (outreach program), and involved cross-faculty involvement (Science and Engineering). It involved a mock math contest, presentations by faculty and entertainment. It was featured in the *Hamilton Spectator*.

Appendix 7: Letter of Support from Gerry Wright, Professor and Chair of Biochemistry and Biomedical Sciences

As Chair of the Department of Biochemistry, I became aware of the innovative programming in the BHSc Program and, in particular, the application of inquiry-based courses a few years ago largely as a result of anecdote and a few positive interactions with some students in the program. This experience lead me to explore further the program and in particular the use of inquiry-based education through conversations with a number of Level I instructors and with Del Harnish, the Assistant Dean in charge of the program. Last term, I had the good fortune to be an instructor in a Level II Inquiry course in the BHSc Program. This game me hands on experience with the format and much greater exposure to students for whom this

innovative form of education is integral to their learning. This course has unequivocally been the high water mark in my 11 years here at McMaster as an undergraduate educator. The students emerging from Level I Inquiry are skilled in information retrieval, evaluation of the myriad sources of this knowledge, group work, self-motivation and oral and written communication. The instructors in Level Inquiry have developed an educational platform that brings out the best in students, forcing them to take an active role in their education rather than having information fed to them through the filter of the instructor. This results in students who are engaged and proactive in their education. With my direct experience, I can say that this facilitates real learning by the students as opposed to the 'memorize it for the exam' approach that pervades other more traditional programs.

I applaud the nomination of Level I Inquiry instructors collectively for this award as together they have developed an approach that both students and instructors find rewarding. In my experience with Level II inquiry, the students were universally eager to take more courses that use this learning style and helpful to me as a novice instructing such a course. This speaks volumes about the Level I preparation they received and the enjoyment students felt with this inquiry process. This very positive outcome ahs served as a great role model of the undergradate programming in my Department and we are now developing a new course using this format and are keen to continue efforts to energize and educate our undergraduates following the BHSc example. The Level I inquiry instructors in the BHSc Program deserve credit for being at the vanguard of this educational revolution here at McMaster that is having a ripple effect throughout the University. This award is well deserved and will draw welcome attention to a group of outstanding educators.

Appendix 8: List of Conferences and Workshops Attended by Teaching Group

Trim, K (June 17, 2004). Inquiry: Does it really work for first-year students? STLHE 2004 Conference, University of Ottawa, Ottawa, ON.

Harnish, D., Landicho, J. (March 5, 2004). Inquiry: A Tried and Successful Design to Promote Learning From First Through Fourth Year. University Of Toronto Mississauga, Mississauga, ON.

Trim, K. (October 22, 2003). Undergraduate Science Education at McMaster University: the Inquiry Experience. Health Sciences Education Rounds, McMaster University, Hamilton, ON.

Trim, K. and Mand-Bains, I. (September 2, 2003). Critical Thinking: What is it? How do we know we've made a difference? T.A. Day 2003 for The Centre for Leadership and Learning, McMaster University, Hamilton, ON.

Trim, K. (June 12, 2003). Critical Thinking: What is it? How do we know we've made a difference? STLHE 2003 Conference, University of British Columbia, Vancouver, BC.

Trim, K., Barrett, S. (March 15, 2003). Inquire, Reflect, Evaluate, and Construct: Essential Skills in Inquiry. 15th Annual Lilly Conference on College and University Teaching – West. International Alliance of Teacher Scholars Inc., Claremont, CA, USA.

Trim, K. (September 4, 2002). Introduction to Self-Directed Learning: Inquiry and Problem-Based Learning. T.A. Day 2002 for The Centre for Leadership and Learning, McMaster University, Hamilton, ON.

Harnish, D., Barrett S., Cardwell, J., Delottinville C., Jordana M., Secord M., Trim, K. (June 15, 2002). Inquiry, Reflect, Evaluate, Construct, Non-Linearity and Crap Detection: Essential University Skills in the Context of the BHSc Programme. STLHE 2002 Conference, McMaster University, Hamilton, ON.

Harnish, D., Landicho, J., Nastos, S. (June 12-15 2002) STLHE Inquiry Experience. STLHE 2002 Conference, McMaster University, Hamilton, ON.

Landicho, J. and Nastos, S. (June 14, 2002). Peer Tutoring in Inquiry: Reflection, Success, Growing Edges. STLHE 2002 Conference, McMaster University, Hamilton, ON.

Trim, K. and Landicho, J. (September 5 2001). Weathering the Storm: Advanced Workshop for Facilitating Self-Inquiry and Problem-Based Learning and Introduction to Self-Directed Learning: Inquiry and Problem-Based Learning. . T.A. Day 2001 for The Centre for Leadership and Learning, McMaster University, Hamilton, ON.

Trim, K., Harnish, D., Lovric, M., Roy, D. (July 9, 2001) Enhancing Self-Directed Learning Opportunities for Science Students: Science Inquiry at McMaster University. HERDSA Conference 2001, July 8-10, 2001. University of Newcastle, Australia.

Trim, K., Cuneo, C., Lovric, M., Maurer, D., **Harnish, D.** (2001) Science Student's Perceptions of Computer Mediated Learning in a Virtual Campus Environment. Presented at the 6th Annual EvNet Conference, May 27-30, Gray Rocks Resort, Mount Tremblant, Quebec.