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# Academic Skill Development - Inquiry Seminars Can Make a Difference: Evidence from a Quasi- experimental Study

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## **Keywords**

Inquiry, Inquiry-based learning, Quasi-experimental study, Academic skills, First-year seminar

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## Academic Skill Development - Inquiry Seminars Can Make a Difference: Evidence from a Quasi-experimental Study

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### Abstract

This paper examines whether a single first-year inquiry-based seminar can have a lasting impact on students' academic skills. Fifty-four Inquiry students and 71 comparable students participated in three performance tests: a research skills exercise; an evaluation of oral presentation ability; and a test of critical reasoning and teamwork skills. In addition, participants completed a questionnaire focusing on learning approaches and experiences. The study demonstrates the feasibility of measuring long-term effects of relatively small educational interventions. Findings indicate that although universities may not be developing the skills they assume, a single first-year inquiry seminar can have far reaching effects on academic skill development and these skills are typically lasting

**Keywords:** Inquiry; inquiry-based learning; quasi-experimental study; academic skills; first-year seminar

### Introduction

The last twenty years has seen increased criticisms of higher educational practice and calls to reform undergraduate programs (e.g. Barr and Tagg, 1995, Boyer Commission, 1998, Bok, 2006). Universities have introduced approaches such as problem-based, experiential, service, and inquiry-based learning to engage students in the learning process and build academic skills. Barr and Tagg (1995) claimed these new innovations represent a paradigm shift from an instructional focus to an approach centered on active engagement and self-directed learning. There has also been a growth in first-year *seminar* courses focused variously on easing the transition to higher education, introducing interdisciplinary themes, developing study and life management skills, and teaching intellectual skills necessary for academic success (Porter and Swing, 2006). In the United States, 90% of colleges and universities offer such first-year seminars to some of their students (Barefoot, 2002).

In order that resources are not wasted on developing courses which have unachievable goals in the time allotted (Bok 2006: 279), curricular design should be based not simply in worthy aims but also in evidence of interventional effectiveness. The shift in pedagogy from

instructor led to self directed learning has raised question about the efficacy of moving in this direction. Van Gelder describes how difficult it is to help students master critical thinking skills. He claims it is about as difficult as learning a new language requiring considerable time and effort (van Gelder, 2005: 42).

While difficult to generalize about the impact of individual first-year seminars, they have been linked to improved retention and improved academic performance measured by GPA and related indicators (e.g.; Fidler, 1991, Williford et. al., 2000-01, Porter and Swing, 2006, Justice et al, 2007). These measures have not explored whether the move to a new pedagogy has contributed to building intellectual and academic skills, or whether effects are significant and lasting -- a noteworthy question given the consensus that skills are best developed when integrated into substantive curricula as opposed to in separate modules (Jenkins & Pepper 1988; Shepherd 2000). Likewise, the effectiveness of inquiry pedagogy in enhancing learning and in producing lifelong learners is largely unexamined, as is the pedagogical significance of linking research and teaching for which inquiry learning may be an important modality (Brew, 1999, Healey, 2005).

The question asked in this paper is: **To what extent can a single first-year inquiry course provide students with academic skills and intellectual habits that will positively impact on their ability to learn?** To answer this question, we describe a quasi-experimental research project measuring the long-term effects (up to 5 years) on students' involvement in a first-year experimental inquiry course offered during the period 1998-2002 at McMaster University. During this time 768 first-year social science or kinesiology students enrolled in Inquiry 1SS3. A preliminary 2002 study of students' academic records comparing Inquiry and non-Inquiry students suggested the seminar had a positive effect on academic performance (Justice, Rice, Warry, & Laurie, 2007) as judged by grades and likelihood of finishing a degree. In order to examine these preliminary findings more deeply, a comprehensive research program was developed in 2004. The McMaster Innovative Learning Study (MILS) was established to examine the ways Inquiry students differed from non-Inquiry students and how these findings might explain differences in academic performance. This paper describes key findings of this study and explores the longer-term consequences associated with taking the inquiry seminar.

### **Inquiry – Pedagogical Objectives**

The intent of Inquiry 1SS3 was to encourage students to develop intellectual and academic skills which we hypothesize leads to active self-directed learners, with life-long learning skills who approach knowledge and understanding deeply, critically and reflectively. Figure 1 sets out the course objectives.

#### **Figure 1: Inquiry 1SS3 Course Objectives**

Students were expected to develop their capacity in the following areas:

- being actively engaged and self-directed in academic research by:
  - engaging a topic
  - developing a good question
  - anticipating the information needed to answer this question
  - accessing and evaluating information
  - synthesizing information into knowledge
  - communicating the inquiry process and new knowledge
  - evaluating success
- enjoying the learning process

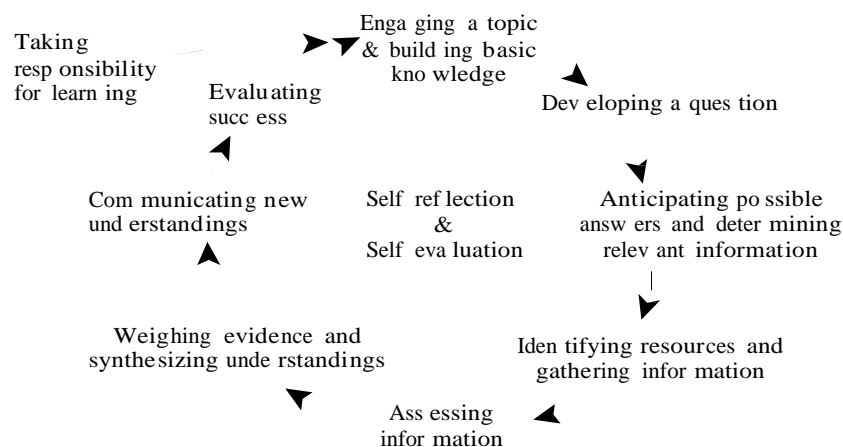
- developing a deep approach to learning
- thinking critically
- reflecting on and evaluating their process as a learner
- learning in collaboration with others
- communicating effectively orally and in writing
- exploring the topical issues of social identity and representation

The Inquiry course design, learning exercises, assessment methods, and guidance given to instructors, are described in two previous publications (Justice, Warry, Cuneo, Inglis, Miller, Rice & Sammon. 2002; Justice, Rice, Warry, Inglis, Miller & Sammon 2007). Here, we summarise the pedagogical logic and those features of the course which are critical to interpreting the results of this study.

The pedagogical theory underlying Inquiry 1SS3 is that students will be more successful in a learning 'ecology' which has four critical features. First, students must be encouraged to explore compelling questions of their own design, with instructors animating this process, acting as resource people and skill developers. Second, necessary intellectual and academic skills need to be introduced at a time when they are required by students to further their inquiries. Third, the environment must be supportive of open-minded discussions, where students are encouraged to question their assumptions and critically assess information. Fourth, students require regular feedback and need to be graded in ways relevant to the skills and abilities underlying the inquiry process.

Inquiry 1SS3 was a limited-enrolment course taught in sections of 20 to 30 students. Sections used a common schedule, reading material, and process of assessment. The classes met for twelve three-hour concurrent evening sessions. All sections investigated aspects of a social science thematic question related to representation of Others. Within this theme, students developed their own individual questions. Weekly classes involved students learning to investigate their questions through the inquiry process represented in Figure 2. Class activities included instructor-guided skills exercises coinciding with the staged development of students' investigations. Skill development tasks were conducted in participatory learning groups of four or five students.

**Figure 2:** The Inquiry Process (from Justice et al. 2007)



## Method of McMaster Innovative Learning Study

### Participants

We offered students \$100.00 to participate in the study. Our goal was to recruit a sample of 80 participants who had taken Inquiry 1SS3 and 80 who had not (from the potential pool of 6244 candidates who had the opportunity to take Inquiry 1SS3 between 1998 and 2002). Students were told only that the study concerned innovative learning. In the end, 54 students who had had taken Inquiry 1SS3 (referred to as 'Inquiry students' or 'Inquiry group') and 71 students who had not taken Inquiry 1SS3 ('Non-Inquiry students' or 'Comparison group') completed the study.

We came to this study well aware of the complexities of conducting research on the living world. A true experiment was neither possible for ethical or practical reasons nor desirable as the presence of disinterested students would change the educational environment. As students were not randomly assigned to the intervention, any measured differences between Inquiry and Non-Inquiry students are potentially related to either the effects of the course or to pre-existing differences between groups related to the self-selection process. We have approached this complexity by: 1) considering the potential for self-selection bias very thoroughly in the planning, execution, analysis and interpretation of the research; 2) clearly acknowledging that student self-selection creates concerns that there are unknown differences between groups including motivation; 3) testing for these differences comparing the groups in all dimensions for which we have data; and 4) drawing inferences about the importance of potential pre-intervention group differences from the study results including questionnaire data and patterns of skill differences.

We tested several variables to see if there were differences between the study groups. As presented in Table 1, there are no meaningful differences between the study groups in gender, age or high school performance, nor in reported parents' income, student loans, or the highest degree student's had earned at the time of study. We cannot directly answer the important question of whether students who chose ISS3 were more academically motivated or not. However, any motivational difference is not reflected in either high school or first-year university performance. Given the similarity between the two groups we felt the differences in performance between 1SS3 students and the comparison group were worth exploring in detail.

**Table 1.** Comparison of variables between Inquiry and Non-Inquiry Students

Level	Means				
	% Female	Age	HS English	HS GPA	Level 1 Avg.
<b>Non-Inquiry</b>	82	19.2	77.0	79.5	6.9
<b>Inquiry</b>	74	19.1	79.3	79.8	7.0
<b>Total</b>	<b>78</b>	<b>19.2</b>	<b>78.1</b>	<b>79.6</b>	<b>6.9</b>

### Instruments

We transformed course objectives (Figure 1) into output indicators to measure student's skills through three sets of exercises, each completed in a two hour period during a single day workshop. The first exercise tested students' academic research skills, including critical thinking and reading skills, question development, research planning, and information gathering. The second exercise evaluated student's videotaped presentations to a small audience. The third examined critical reasoning and teamwork ability. In addition, participants completed an online questionnaire exploring approaches to learning, academic and social activities, attitudes, perceptions, satisfaction, and self-perceived change during university.

## Analysis Procedures

To ensure objective assessment of students' performance, multiple blinded Raters who were educators from outside the university or extensively trained graduate students assessed the results of the exercises. Differences between study groups were compared using analysis of variance procedures. The main thrust of our statistical analysis is the calculation of effect size, a measure of the magnitude or importance of a treatment effect which is independent of the size of the sample using Cohens  $d$  (Cohen, 1988). We also calculated probability value in the standard way, but this is not meant as a stand-alone test of differences. Because we were testing for the effects of a single course in the context of as many as 40 courses and after as many as five years, we did not expect to see large effects. In addition, because our analyses needed to control for university level, the added variance related to multiple instructors, and our small sample size, we expected to see low effect sizes and relatively high  $p$  values. Though there are many results which are statistically significant according to the classical criteria of  $p < 0.05$ , we decided to accept differences as *meaningful* if they have a minimum effect size of 0.2 (which Cohen considers to be a small effect) in combination with a reasonable probability value which, we judge to be 0.2.

Because we were testing skills generally developed at university, we also controlled for the number of courses a student had taken as a measure of time spent at university or university exposure. Students were grouped dichotomously into Lower-Level students (who had completed fewer than 84 units) and Upper-Level students (more than 84 units). Lower-Level students, on average, had about half the university experience compared to Upper-Level students: a difference of 53.2 units, or just less than two full years.

**Table 2.** Comparison of variables between levels

Level	Means				
	% Female	Age*	HS English	HS GPA	Level 1 Avg
<b>Lower Level</b>	78	19.1	77.4	79.4	6.7
<b>Upper Level</b>	79	19.2	78.6	79.9	7.2
<b>Total</b>	<b>78</b>	<b>19.2</b>	<b>78</b>	<b>79.6</b>	<b>6.9</b>

\* Age when course was taken

As there are no cohort differences between dichotomous level groups (Table 2), we believe it is reasonable to conclude that when we compare skill levels between Lower and Upper-Level students (controlling for study group) we are seeing the effects of time spent at university. In the tables that follow, we compare performance differences between study groups with those between Lower- and Upper-Level students. This provides a sense of the relative strength of the effect of being in one or the other study group to the effect of being in university for two full years.

In the following tables, scores are reported as estimated marginal means scaled to percentiles. Bolded results are those we consider meaningful with effect size higher than 0.20 and  $p$  value of less than 0.20. Figures with Source labeled Group or Level are comparisons by study group and university level respectively. Figures with Source labeled Lower or Upper represent interactions of group and level.

## Questionnaire Results

The questionnaire consisted of 140 questions related to approaches, attitudes to learning and experiences of university. Questions were designed to either discover any pre-existing differences between groups that might alternatively explain study effects or to measure change associated with having taken the Inquiry seminar.

The Revised Study Process Questionnaire Biggs, Kember & Leung, (2001) examines deep and surface approaches to learning. We found no main effects either between the Inquiry group and the Comparison group or between Lower and Upper-Level students. This suggests that neither being in the Inquiry seminar nor time spent at university has much of an impact on students' approach to learning. However, among Non Inquiry group more time spent at university is associated with a *decrease* in deep approach to learning suggesting the Inquiry seminar provided a small protective effect against a more general decrease in deep approach to learning.

**Table 3.** Life Long Learning

Variable	Source	Estimated Marginal Means			ANOVA	
		Non-Inquiry	Inquiry	Effect size	F	p.
Making Sense of Course Material	Group	68.1	67.8	.036	.040	.842
	Lower	67.4	66.6	.072	.128	.721
	Upper	68.8	69.0	.020	.128	.721
Being Self-Directed	Group	79.5	80.4	.088	.192	.662
	Lower	<b>80.4</b>	<b>83.8</b>	<b>.246</b>	<b>1.688</b>	<b>.196</b>
	Upper	78.7	77.0	.122	1.688	.196
Being Guided by Others	Group	51.0	47.9	.308	1.424	.235
	Lower	<b>53.5</b>	<b>45.5</b>	<b>.574</b>	<b>3.826</b>	<b>.053</b>
	Upper	48.4	50.3	.139	3.826	.053
		Lower Level	Upper Level			
Making Sense of Course Material	Level	<b>67.0</b>	<b>68.9</b>	<b>.210</b>	<b>1.669</b>	<b>.199</b>
Being Self-Directed	Level	<b>82.1</b>	<b>77.8</b>	<b>.388</b>	<b>4.746</b>	<b>.031</b>
Being Guided by Others	Level	49.5	49.4	.015	.004	.949

The Life Long Learning Scale (Knapper and Cropley 2000) showed a similar pattern. There were no main effects related to being in the Inquiry group nor to time spent in university. However, a factor analysis revealed three components: *Making Sense of Course Material*, *Being Self-Directed* and *Being Guided by Others* (Table 3), and we found meaningful effects in the component *Being Self-Directed*. Lower-Level students score higher than Upper-Level students suggesting that self-perception of being self-directed *diminishes* with time spent in university. Among Lower-Level students only, Inquiry students score meaningfully higher in *Being Self-Directed* than the Non-Inquiry students and lower in *Being Guided by Others*. This suggests that Inquiry 1SS3 had some positive effect on the self-perception of being a self-directed learner and a positive effect against the self-perception of being guided by others. However, this effect does not persist, perhaps because the university environment has an overall negative effect on the self-perception of development of life-long learning traits.

Other questionnaire items pertained to experiences in and engagement in both academic and non-academic activities. Results are shown in Table 4.



**Table 4.** Engagement and Experience Questionnaire Results

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
<i>Engagement</i>						
	Group					
Scholastic Engagement		53.1	52.6	.048	.070	.792
Scholastic Disengagement		46.6	42.4	.215	1.396	.240
Broad Scholastic Interest		<b>25.7</b>	<b>29.9</b>	<b>.246</b>	<b>1.815</b>	<b>.180</b>
Academic Community Engagement		28.2	31.9	.196	1.153	.285
Engagement with Professors		27.7	28.7	.032	.030	.862
Involvement in University life		50.7	51.6	.076	.176	.676
Work and Family Activities		<b>35.0</b>	<b>27.6</b>	<b>.354</b>	<b>3.763</b>	<b>.055</b>
<i>Rating of Experience</i>						
Satisfaction with University		62.6	61.9	.049	.071	.790
Skill development at University		<b>77.9</b>	<b>83.3</b>	<b>.713</b>	<b>15.309</b>	<b>.000</b>
Successful socialization at University		75.9	74.2	.123	.452	.503
Would you still choose McMaster?		<b>82.0</b>	<b>87.0</b>	<b>.269</b>	<b>2.085</b>	<b>.151</b>
		Lower Level	Upper Level			
<i>Engagement</i>						
	Level					
Scholastic Engagement		<b>49.8</b>	<b>55.9</b>	<b>.546</b>	<b>9.374</b>	<b>.003</b>
Scholastic Disengagement		46.6	42.4	.215	1.455	.230
Broad Scholastic Interest		26.1	29.5	.197	1.220	.272
Academic Community Engagement		29.7	30.3	.031	.031	.861
Engagement with Professors		<b>18.4</b>	<b>38.0</b>	<b>.601</b>	<b>11.362</b>	<b>.001</b>
Involvement in University life		<b>49.1</b>	<b>53.1</b>	<b>.328</b>	<b>3.378</b>	<b>.069</b>
Work and Family Activities		29.8	32.8	.143	.640	.425
<i>Rating of Experience</i>						
Satisfaction with University		60.7	63.9	.209	1.378	.243
Skill development at University /		<b>78.9</b>	<b>82.3</b>	<b>.435</b>	<b>5.943</b>	<b>.016</b>
Successful socialization at University		<b>72.3</b>	<b>77.8</b>	<b>.408</b>	<b>5.242</b>	<b>.024</b>
Would you still choose McMaster?		82.9	86.1	.172	.890	.348

As would be expected, time spent at university has a number of independent effects. Upper-Level students report higher levels of scholastic engagement, involvement in university activities and increased connection to professors. These students, more than Lower-level students, also perceive themselves as having succeeded at university and as having developed more skills.

By and large, there are few meaningful differences between the Inquiry group and the Comparison group in these areas. Inquiry group students report fewer part-time jobs and family responsibilities that interfere with studying. Perhaps correspondingly, Inquiry students reported higher levels of indicators of broad scholastic interest. Given their university experience, Inquiry students were also more likely to say that they would still choose McMaster again. In another question about general preference to work independently or as a part of a team, 39% of the Inquiry group said they prefer teamwork against 26% of the Comparison group.

**Table 5.** Perceived development of skills while at university

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
Knowledge and Academic Skills	Group	<b>85.8</b>	<b>90.2</b>	<b>.564</b>	<b>9.578</b>	<b>.002</b>
Social Awareness		<b>76.7</b>	<b>82.6</b>	<b>.470</b>	<b>6.662</b>	<b>.011</b>
Interpersonal skills		<b>73.4</b>	<b>81.8</b>	<b>.634</b>	<b>12.098</b>	<b>.001</b>
Understanding other cultures		<b>71.0</b>	<b>75.1</b>	<b>.388</b>	<b>4.526</b>	<b>.035</b>
Computer skills		<b>75.7</b>	<b>80.6</b>	<b>.340</b>	<b>3.472</b>	<b>.065</b>
Knowledge and Academic Skills	Level	Lower Level	Upper Level			
Knowledge and Academic Skills		<b>86.4</b>	<b>89.6</b>	<b>.406</b>	<b>5.192</b>	<b>.024</b>
Social Awareness		<b>78.2</b>	<b>81.2</b>	<b>.237</b>	<b>1.760</b>	<b>.187</b>
Interpersonal skills		<b>74.1</b>	<b>81.1</b>	<b>.516</b>	<b>8.361</b>	<b>.005</b>
Understanding other cultures		72.7	73.4	.067	.142	.707
Computer skills	<b>75.8</b>	<b>80.5</b>	<b>.315</b>	<b>3.130</b>	<b>.079</b>	

There is, however, one area of striking difference between Inquiry and Non-Inquiry students in the questionnaire data: student perceptions of their development in 14 skills. Factor analysis resulted in five components, presented in Table 5.

As would be expected, there is a significant effect related to time spent at university. Upper-Level students report greater skill development than Lower-Level students in all components except one related to *Understanding Other Cultures*. Remarkably, Inquiry students report greater skill development than do the Non-Inquiry students in all components and with effect sizes more substantial than that between Upper and Lower-Level students. As the difference between groups does not diminish with time spent at university this evidence suggests that the effects of the course on the way students recognize their academic skills were persistent. This area of difference between study groups is logically related to the Inquiry seminar which explicitly dealt with skill development and skill recognition.

Overall, the questionnaire responses suggest Inquiry students are not much different from the comparison group when it comes to their experiences of university, their approaches to learning, and in the way they value education. However, compared to other students, Inquiry students *believe* they have changed in fundamental ways: they believe they have developed greater social awareness, better interpersonal skills, and more understanding of diversity. They also believe they have developed more in both knowledge and academic skills. But have they?

### Exercise 1 – Academic Research Skills

This set of four linked tasks conducted over a two hour period tested academic research skills. Students were asked to 1) read and summarize an academic paper, 2) design a question and a research plan, 3) find good information relevant to the question, and 4) carry out a self-evaluation of performance and ability. This material was graded by three trained Raters who were blind to the study design. Raters used a validated scoring sheet adapted from Trim (2006) to score each exercise. Raters assessed the critical thinking exhibited in the first two exercises and the quality of the four exercises as a whole. Inter-Rater reliability was acceptable (Cronbach's Alpha = .878).

#### Component 1 - Reading and Summarizing Material

Students were given a reasonably short, complex and controversial research article (Duncan 2003) and asked to write a 200 word summary in a 40-minute period. Raters assessed these summaries for their clarity, accuracy and apparent understanding of the research paper (*Clarity and Accuracy of Summary*) and holistically rated the overall summary quality. The results are presented in Table 6.

For both measures, Raters judged Inquiry students' work more highly than that of the Comparison group. For the factor *Clarity and Accuracy of Summary* the difference between study groups is bigger than that associated with time spent in university. This skill advantage does not diminish with time.

**Table 6.** Quality of article summaries

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
Overall quality of Summary	Group	<b>62.4</b>	<b>66.1</b>	<b>.259</b>	<b>2.041</b>	<b>.154</b>
Clarity and Accuracy of Summary		<b>66.8</b>	<b>72.4</b>	<b>.306</b>	<b>8.346</b>	<b>.004</b>
		Lower Level	Upper Level			
Overall quality of Summary	Level	<b>61.4</b>	<b>67.1</b>	<b>.396</b>	<b>4.890</b>	<b>.028</b>
Clarity and Accuracy of Summary		67.8	71.5	.199	3.694	.055

Raters also assessed student summaries on the basis of their *critical intentionality* or what aspects of the research paper students chose to focus on. The analysis revealed three factors: *Focusing on Factual Details*, *Focusing on Author's Argument*, and *Focusing on Research Methods*. The results are presented in Table 7. Time spent at university is associated with higher scores related to focusing on methodology and the factual details of the article. Lower-Level Inquiry students were more likely to focus their summaries on the factual details and Upper-Level Inquiry students were less likely to focus on methodology. This assessment of critical intentionality shows Inquiry students approach the writing of summaries differently than the Comparison group and suggests that better capturing of factual details is associated with higher summary ratings.

**Table 7.** Critical intentionality of summaries

Variable	Source	Estimated Marginal Means		ANOVA		
		Non-Inquiry	Inquiry	Effect size	F	p.
Focusing on Factual Details	Group	<b>63.5</b>	<b>68.4</b>	<b>.243</b>	<b>5.258</b>	<b>0.022</b>
	Lower	<b>58.2</b>	<b>69.1</b>	<b>.536</b>	<b>7.632</b>	<b>0.006</b>
	Upper	68.7	67.7	.050	7.632	0.006
Focusing on Author's Argument	Group	18.7	22.0	.145	1.869	0.172
	Lower	17.5	22.1	.199	0.260	0.611
	Upper	19.9	22.0	.092	0.260	0.611
Focusing on Research Methods	Group	42.1	39.4	.131	1.536	0.216
	Lower	37.6	38.0	.015	1.912	0.168
	Upper	<b>46.5</b>	<b>40.9</b>	<b>.282</b>	<b>1.912</b>	<b>0.168</b>
Focusing on Factual Details	Level	<b>63.7</b>	<b>68.2</b>	<b>.220</b>	<b>4.523</b>	<b>0.034</b>
Focusing on Author's Argument	Level	19.8	20.9	.047	0.203	0.652
Focusing on Research Methods	Level	<b>37.8</b>	<b>43.7</b>	<b>.284</b>	<b>7.535</b>	<b>0.006</b>

### Component 2 - Research Project Design

Students were asked to design research they would do related to the article they had just summarized. They were asked to write down questions or ideas related to the article, to develop one question suitable for research, to explain why this question is appropriate, and finally to outline a realistic research plan for their question, identifying both specific information and procedures for finding evidence. Raters scored the material in two areas 1) apparent ability to design a good research question and; 2) ability to outline a good research plan.

Raters judged the overall quality of the research question (Table 8), both using their own subjective considerations and by attributing 'desirable qualities' to the question from a supplied list. They also rated justifications of why the question was appropriate. The list of desirable qualities included analytical approach; focus on a dilemma or problem; openness to possible answers; theoretical foundation; relevance to the original paper, creativity; research ability; and social importance. In the assessment of question quality, Lower-Level Inquiry students received meaningfully higher scores than did the comparisons. However, for Upper-Level students the Non-Inquiry group received higher scores. In counting desirable qualities, Inquiry students' questions had fewer desirable qualities than those of the comparisons but at the Upper-Level only. Finally, Inquiry students offer significantly fewer good reasons why their question is appropriate than the Non-Inquiry group. These mixed results suggest an initial, small, but non-persistent advantage to inquiry students in the ability to design a good question. However, overall Inquiry is associated with a net disadvantage in ability to design or describe a research question.

**Table 8. Question Quality and Justification**

Variable	Source	Estimated Marginal Means		Effect size	ANOVA		
		Non-Inquiry	Inquiry		F	p.	
Number of desirable qualities of research question	Group	<b>43.3</b>	<b>40.0</b>	<b>.316</b>	<b>3.026</b>	<b>.083</b>	
	Lower	40.3	40.8	.048	4.035	.045	
	Upper	<b>46.3</b>	<b>39.2</b>	<b>.700</b>	<b>4.035</b>	<b>.045</b>	
Overall quality of the research question.	Group	62.7	60.5	.151	0.700	.403	
	Lower	<b>57.3</b>	<b>61.8</b>	<b>.313</b>	<b>6.490</b>	<b>.011</b>	
	Upper	<b>68.2</b>	<b>59.2</b>	<b>.612</b>	<b>6.490</b>	<b>.011</b>	
Number of good reasons given why question is appropriate	Group	<b>8.4</b>	<b>5.5</b>	<b>.454</b>	<b>6.291</b>	<b>.013</b>	
	Lower	7.7	4.2	.546	0.209	.648	
	Upper	9.1	6.7	.373	0.209	.648	
Overall quality of justification of question appropriateness	Group	55.4	55.5	.004	.000	.984	
	Lower	<b>53.9</b>	<b>50.2</b>	<b>.239</b>	<b>1.809</b>	<b>.180</b>	
	Upper	<b>56.9</b>	<b>60.7</b>	<b>.248</b>	<b>1.809</b>	<b>.180</b>	
Number of desirable qualities of research question	Level	Lower Level	40.5	43.8	.212	1.392	.239
		Upper Level	<b>59.5</b>	<b>63.7</b>	<b>.282</b>	<b>2.458</b>	<b>.118</b>
Overall quality of the research question.	Level	<b>6.0</b>	<b>7.9</b>	<b>.292</b>	<b>2.653</b>	<b>.104</b>	
Number of good reasons given why question is appropriate	Level	<b>52.1</b>	<b>58.8</b>	<b>.428</b>	<b>5.746</b>	<b>.017</b>	
Overall quality of justification of question appropriateness	Level						

Research Planning is represented by a summation of Raters' scores (Table 9) in four areas: 1) plan specificity, 2) plan practicality, 3) likelihood of resulting in good data, and 4) familiarity with diverse methods. There is a slight improvement in this skill with time spent at university. There is no overall group difference between Inquiry students and the Comparison group in research planning. However, there is a significant interaction effect. Lower-Level Inquiry students score higher at planning research than the Lower-Level Non-Inquiry group, but this pattern is reversed among Upper-Level students where the comparison group scored higher.

**Table 9.** Student's Research Plan

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
Quality of the Student's research plan (summary of four areas)	Group	55.3	54.4	.074	0.164	.685
	Lower	<b>50.2</b>	<b>56.6</b>	<b>.542</b>	<b>11.274</b>	<b>.001</b>
	Upper	<b>60.4</b>	<b>52.2</b>	<b>.680</b>	<b>11.274</b>	<b>.001</b>
Quality of the Student's research plan(summary of four areas)	Level	Lower Level	Upper Level	.242	<b>1.824</b>	<b>.178</b>
		<b>53.4</b>	<b>56.3</b>			

### Component 3 –Critical Thinking

To judge critical thinking, Raters considered both the article summaries and the research plan described above. Raters looked for evidence of four critical activities: 1) conveying meaning in the words and concepts (interpretation), 2) conveying comprehension of the overall meaning (analysis), 3) questioning whether the text makes sense or whether the findings are valid or reliable (evaluation); and 4) drawing conclusions from the student's understanding of the text or making connections to previous knowledge (inference). A second aspect of the assessment of critical thinking was Raters' subjective assessment of the student's apparent ability to *think critically*. There are no meaningful differences between Inquiry group and the Comparison group and only a small positive effect between Upper and Lower-Levels in one measure of critical thinking suggesting university experience has a small beneficial effect on critical thinking.

**Table 10.** Critical thinking in article summarizing and research planning

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
Critical thinking (summary of four questions)	Group	62.2	58.5	.234	1.643	.201
	Lower	61.8	54.9	.437	1.204	.273
	Upper	62.6	62.0	.033	1.204	.273
Assessment of critical thinking ability	Group	69.3	67.9	.098	0.358	.550
	Lower	68.6	65.5	.228	0.421	.517
	Upper	70.1	70.2	.009	0.421	.517
Critical thinking (summary of four questions)	Level	Lower Level	Upper Level	.246	<b>1.884</b>	<b>.171</b>
		<b>58.3</b>	<b>62.3</b>			
Assessment of critical thinking ability	Level	70.1	67.0	.217	1.469	.226

### Component 4 - Accessing Information

Following the research planning exercise, students were given a set question and asked to find quality information to help them answer this question. They were asked to list as many

relevant and useful articles, books and websites as they could find, and to identify the 3 journal articles, 3 academic books and 3 trustworthy (non journal) web sites that they found the most useful. Raters assessed both the students' abilities at locating useful information and the process as a whole. (Table 11).

**Table 11.** Accessing Information Results

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
Accessing Journals	Group	<b>51.3</b>	<b>58.4</b>	<b>.503</b>	<b>7.638</b>	<b>.006</b>
	Lower	<b>40.4</b>	<b>54.8</b>	<b>1.057</b>	<b>8.487</b>	<b>.004</b>
	Upper	<b>62.3</b>	<b>61.9</b>	<b>.027</b>	<b>8.487</b>	<b>.004</b>
Accessing Books	Group	47.5	47.2	.017	0.008	.928
	Lower	<b>41.2</b>	<b>47.6</b>	<b>.420</b>	<b>5.667</b>	<b>.018</b>
	Upper	<b>53.8</b>	<b>46.9</b>	<b>.447</b>	<b>5.667</b>	<b>.018</b>
Accessing Web Material	Group	47.5	45.2	.152	0.701	.402
	Lower	45.9	41.2	.308	0.709	.400
	Upper	49.2	49.2	.001	0.709	.400
Holistic Rating of Information Accessing	Group	51.9	52.1	.014	.006	.937
	Lower	<b>44.7</b>	<b>49.7</b>	<b>.433</b>	<b>5.140</b>	<b>.024</b>
	Upper	<b>59.1</b>	<b>54.4</b>	<b>.396</b>	<b>5.140</b>	<b>.024</b>
Accessing Journals	Level	Lower Level	Upper Level			
		<b>47.6</b>	<b>62.1</b>	<b>1.020</b>	<b>32.411</b>	<b>.000</b>
Accessing Books	Level	<b>44.4</b>	<b>50.3</b>	<b>.382</b>	<b>4.549</b>	<b>.034</b>
Accessing Web Material	Level	<b>43.5</b>	<b>49.2</b>	<b>.363</b>	<b>4.112</b>	<b>.043</b>
Holistic Rating of Information Accessing	Level	<b>47.2</b>	<b>56.8</b>	<b>.809</b>	<b>20.172</b>	<b>.000</b>

Upper-Level students score significantly higher than Lower-Level students in all aspects of our measures of accessing information, indicating that this is a skill set that students improve upon in attending university. Lower-Level Inquiry students score higher than Lower-Level Non-Inquiry students on *accessing journal articles*. It seems that Inquiry students are given an advantage in this area and, though they continue to improve with time, the Comparison group students catch up by Upper-Level. While taking Inquiry 1SS3 has no effect overall on *accessing books*, there is an interaction with level. Lower-Level Inquiry students have an advantage but they do not seem to progress and Upper-Level Inquiry students are at a disadvantage. There are no group differences in *accessing useful websites*.

These results make sense given the Inquiry seminar training, which focused primarily on finding journal articles, only somewhat on books, and with the assessing, but not the finding, of web-based material. We take the overall pattern of these results as evidence that effects more generally can be linked to the course and not to pre-existing group differences. The Holistic Rating of Information Accessing shows a similar pattern to question development and research planning; Inquiry students have an advantage in the first couple of years after taking the seminar, but in later years they score less well than Non-Inquiry students.

### Component 5 - Self-assessment

In the final research skills task, students were asked evaluate their strengths and need for improvement in the previous areas. Raters examined student self-assessments and scored them according to their willingness to self-assess, their open-mindedness to strengths and weaknesses, their analytical self-confidence, and their inquisitiveness regarding multiple points of view. These responses were summed to create a component *Student Self-Assessment*. In addition, the Raters provided a holistic impression of self assessments, referred to as *Overall Rating*.

**Table 12. Self-assessment**

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
Student Self-Assessment	Group	<b>56.6</b>	<b>59.4</b>	<b>.291</b>	<b>2.544</b>	<b>.112</b>
Overall Rating	Group	<b>59.0</b>	<b>63.6</b>	<b>.382</b>	<b>4.41</b>	<b>.036</b>
		Lower Level	Upper Level			
Student Self-Assessment	Level	<b>56.6</b>	<b>59.4</b>	<b>.286</b>	<b>2.549</b>	<b>.111</b>
Overall Rating	Level	<b>59.5</b>	<b>63.2</b>	<b>.304</b>	<b>2.907</b>	<b>.089</b>

Inquiry students were judged to be better at self-evaluation relative to the Comparison group in both measures and with a magnitude similar to the difference between Upper-Level and Lower-Level students, roughly equivalent to two full years of university experience.

### Component 6 – Holistic Assessment of Academic Research Skills

Finally, Raters considered their overall impression of the academic research skills exercises not taking into account the component scores for the four parts of the exercise. Despite the mixed results for some of the research exercise tasks when rated as individual components, when Raters judged research skills holistically Inquiry was associated with higher overall scores with a medium effect size. The magnitude of this advantage is similar to that between Upper-Level and Lower-Level students, suggesting an independent effect similar to two years of university. An interaction effect shows the advantage of having taken Inquiry 1SS3 is more significant among Lower-Level students. This relates to skill development of the comparison group in this area between Lower and Upper-Levels. The skill levels developed by the Inquiry students early are lasting and continue to develop between Lower and Upper Levels (Table 13).



**Table 13.** Holistic Assessment of Academic Research Skills

Variable	Source	Estimated Marginal Means		Effect size	ANOVA	
		Non-Inquiry	Inquiry		F	p.
Inquiry Exercises Overall	Group	<b>55.5</b>	<b>61.7</b>	<b>0.489</b>	<b>7.134</b>	<b>0.008</b>
	Lower	<b>50.8</b>	<b>60.0</b>	<b>0.739</b>	<b>1.797</b>	<b>0.181</b>
	Upper	<b>60.3</b>	<b>63.4</b>	<b>0.241</b>	<b>1.797</b>	<b>0.181</b>
Inquiry Exercises Overall	Level	Lower Level <b>55.4</b>	Upper Level <b>61.8</b>	<b>0.499</b>	<b>7.846</b>	<b>0.005</b>

### Oral Presentation

This exercise tested student's abilities at designing and conducting an effective oral presentation. Students were assigned to small work groups and given 20 minutes to prepare a five-minute oral presentation based on a list of key-words. Students then made oral presentations to the other members of their groups. Videotapes of 124 presentations were sent to volunteer Raters who were educators from universities across Canada. Each Rater 'blindly' scored approximately 60 presentations; three Raters independently rated each presentation. Inter-rater reliability is acceptable (Cronbach's Alpha, .823.). Raters provided a global percentage score for each presentation and scores on six components which were summed to create a single variable: *Rating Summary*. The results are presented in Table 14.

**Table 14.** Oral presentations

Variable	Source	Estimated Marginal Means		Effect size	MANOVA	
		Non-Inquiry	Inquiry		F	p.
Global Score	Group	<b>66.8</b>	<b>68.7</b>	<b>.331</b>	<b>3.218</b>	<b>.074</b>
	Lower	66.0	69.3	.558	1.527	.217
	Upper	67.5	68.1	.103	1.527	.217
Rating Summary of 6 Quality Questions	Group	<b>60.3</b>	<b>63.3</b>	<b>.320</b>	<b>3.002</b>	<b>.084</b>
	Lower	<b>58.1</b>	<b>64.8</b>	<b>.688</b>	<b>3.996</b>	<b>.046</b>
	Upper	62.5	62.0	-.049	3.996	.046
Global Score	Level	Lower Level 67.6	Upper Level 67.8	-.030	.029	.865
Rating Summary of 6 Quality Questions	Level	61.5	62.2	-.079	.198	.656

By both global and summed measures of quality, Inquiry student presentations were scored meaningfully higher than those of the Comparison group. Interestingly, time at university has no effect in developing this skill area. We also looked individually at the component questions.

**Table 15.** Component questions of summed variable

Variable	Source	Estimated Marginal Means			MANOVA	
		Non-Inquiry	Inquiry	Effect size	F	p.
Effectiveness	Group	<b>62.0</b>	<b>66.0</b>	<b>.391</b>	<b>4.476</b>	<b>.035</b>
	Lower	<b>59.2</b>	<b>67.6</b>	<b>.736</b>	<b>3.534</b>	<b>.061</b>
	Upper	63.9	64.4	.044	3.534	.061
Clarity	Group	<b>66.0</b>	<b>68.0</b>	<b>.298</b>	<b>2.600</b>	<b>.108</b>
	Lower	<b>63.6</b>	<b>71.0</b>	<b>.694</b>	<b>4.647</b>	<b>.032</b>
	Upper	67.7	66.6	-.100	4.647	.032
Style	Group	58.0	58.0	.129	.491	.484
	Lower	<b>54.3</b>	<b>60.3</b>	<b>.499</b>	<b>4.024</b>	<b>.046</b>
	Upper	<b>60.5</b>	<b>57.6</b>	<b>-.241</b>	<b>4.024</b>	<b>.046</b>
Organization	Group	<b>64.0</b>	<b>66.0</b>	<b>.286</b>	<b>2.403</b>	<b>.122</b>
	Lower	<b>61.2</b>	<b>67.7</b>	<b>.567</b>	<b>2.337</b>	<b>.127</b>
	Upper	65.7	65.7	.004	2.337	.127
Creativity	Group	52.0	54.0	.229	1.545	.215
	Lower	49.4	55.3	.459	1.563	.212
	Upper	52.9	52.9	-.001	1.563	.212
Enjoyability	Group	<b>62.0</b>	<b>66.0</b>	<b>.283</b>	<b>2.346</b>	<b>.126</b>
	Lower	61.0	66.7	.512	1.558	.213
	Upper	64.1	64.7	.052	1.558	.213
Effectiveness	Level	Lower Level	Upper Level			
		63.4	64.1	-.061	.117	.732
Clarity		67.3	67.2	.009	.003	.959
Style		57.3	59.1	-.144	.655	.419
Organisation		64.5	65.7	-.105	.349	.555
Creativity		52.4	52.9	-.041	.054	.816
Enjoyability		63.9	64.4	-.048	.074	.786

Inquiry presentations were rated meaningfully higher than Non-Inquiry ones in effectiveness, clarity, organisation and enjoyability, but not in style or creativity. No meaningful differences existed between Lower and Upper-Level students in any of the categories. Almost all of the differences between Inquiry and Non-Inquiry students occur only among Lower-Level students. Inquiry students are only better off for one or two years after taking the course. It appears that this skill set, clearly developed by taking Inquiry 1SS3, is attenuated with time in an environment which does not develop or nurture these skills.

### Critical Reasoning and Team Performance Exercise

This exercise, an adaptation of Nemiroff and Pasmore's classic simulation "Lost at Sea" (2003, 1975), measured students' abilities in critical reasoning (the process of evaluating and ranking information when students' synthesize new knowledge), participatory learning,

and self-evaluation. Students were placed in four to six member teams consisting of either Inquiry students or Non-Inquiry students. Each team member individually ranked the importance of fifteen survival items for an imagined scenario of being stranded on a raft following a boating accident. Students then worked as a team to reach a consensus ranking of the same fifteen items. Our adaptation involved a third individual ranking following the team ranking. Finally, students completed a questionnaire evaluating their own and their team's performance.

We calculated the values of and differences between student pre-scores, team consensus score and student post-scores. Differences between pre-score and team consensus score represent a measure of group functioning; better functioning groups should make greater improvements than individuals or poorer functioning groups. We take the difference between the team consensus and individual post scores, to be a measure of satisfaction with the group consensus. Table 16 shows results only by study group as there were no differences between Lower and Upper –Level students, suggesting time spent at university has no effect in this area. There are, however, some independent effects related to study group membership. Inquiry students scored higher than Non-Inquiry students in this exercise in all three rankings related to critical reasoning.

**Table 16.** Team Critical Reasoning Exercise

<i>Scores</i>	Estimated Marginal Means		Effect size	ANOVA	
	Non-Inquiry	Inquiry		F	p.
Individual Pre-score	<b>42.8</b>	<b>46.6</b>	<b>.283</b>	<b>2.391</b>	<b>.125</b>
Team Consensus Score	51.7	54.4	.239	1.488	.225
Individual Post-score	<b>49.5</b>	<b>54.2</b>	<b>.389</b>	<b>3.950</b>	<b>.049</b>
<i>Differences</i>					
Team score - Pre-score	9.3	8.1	-.084	0.183	0.669
Pre-score - Post-score	7.1	7.9	.055	0.078	0.781
Post-score - Team score	<b>-2.2</b>	<b>-0.2</b>	<b>-.350</b>	<b>3.193</b>	<b>0.077</b>
Absolute Difference of Post-score - Team score	4.4	4.0	.085	0.187	0.666

It appears that the consensus building exercise is generally effective in moving toward the correct answer set as scores on average were better for teams than for individuals. However both groups improved about the same amount between the individual and team scores, and thus there is no evidence for a group difference in team and or participatory learning skills. Likewise, we did not find meaningful differences between Inquiry and Non-Inquiry students in our absolute measure of change from the team ranking to the post ranking exercise. However, Non-Inquiry students scored slightly worse by departing from their consensus scores, Inquiry students did not. This suggests that while Inquiry students are no more confident in their team's consensus work, they benefited as individuals more from being in the group, an advantage also reflected in the increased advantage for Inquiry students in post-scores. Students' self-evaluation of individual and team performance showed little differences by study group or level.

## Discussion

We are mindful of the limits of quasi-experimental research especially regarding the issue of student self-selection into the Inquiry 1SS3 course. We also recognize that as faculty investigators we have a vested interest in the success of our intervention. In our analysis we have identified a number of potential limitations; we ask readers to share our caution in considering the study's results. We wish to make four observations from this research: it is feasible to see and measure the effects of relatively small educational interventions on students' abilities even after several years; university curriculum may not develop the skills many faculty members and students assume it is developing; a single, one-semester course can have relatively far reaching effects in academic skill development; and these skills can be lasting.

### Measuring Changes in Student's Abilities

This study demonstrates that it is possible to detect changes in students' academic skills and abilities with a quasi-experimental methodology and a relatively small sample, using instruments designed to test actual differences in skill performance as well students' appraisals and self-reports. The instruments detected not only small and meaningful differences between Lower-Level and Upper-Level students, representing about two years of time spent at university, but also differences related to the taking of a one three unit first-year course. Some study participants took 1SS3 five years prior to our tests and Inquiry was only one of forty total university courses. The methodology detected differences between Inquiry and Non-Inquiry students in self-reported attitudes, experiences and activities, and in skill-related performance.

Two methodological points are worth making. First, by and large, directly tested skills showed more meaningful differences than could be seen in the self-reported questionnaire data. This may suggest that evaluations of educational interventions that rely on questionnaire data alone may not be as sensitive as methodological designs that directly measure student learning. Second, holistic ratings can be different than the sum of the parts. For example, despite quite mixed results on some components of academic research skills, when the Raters considered the tasks holistically, Inquiry students appeared to have clearly performed better than the comparisons.

Our sample included students who self-selected to either take or not take Inquiry 1SS3. This raised the possibility that differential effects in ability are artifacts of pre-existing differences between students. However, the method allowed us to draw conclusions about this likelihood based on analysis of the overall pattern of correspondence between Inquiry seminar foci and measured skill levels related to group membership on the one hand and to time spent in university on the other. For example, the fact that Inquiry students perceive themselves to have developed in two areas *Understanding Other Cultures* and *Social Awareness*, areas in which time spent at university has no independent effect and a slight independent effect respectively, links this enhanced perception of skill development to Inquiry 1SS3, which took these areas as thematic content. A second example is correspondence between inquiry group performance and Inquiry seminar foci in the skills of finding research materials. In sum, this research supports the feasibility of conducting effective evaluative research documenting the long-term effects of a wide variety of educational interventions.

### University Curriculum May Not Address the Skills It Is Assumed to Develop

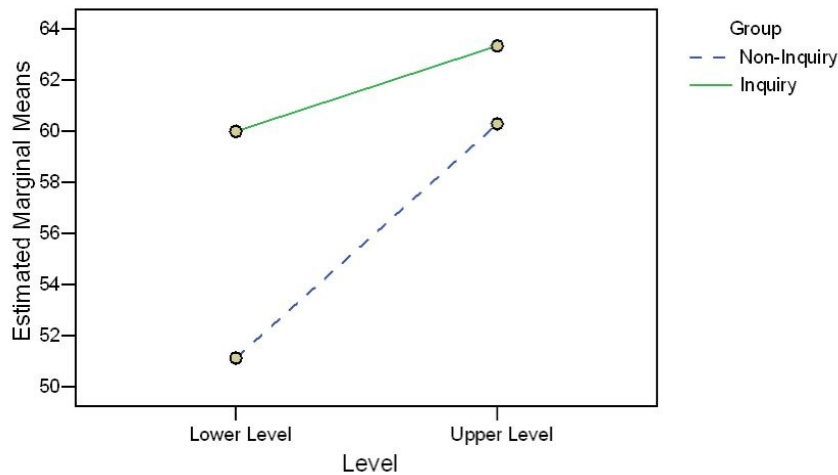
Although an unintended consequence of the research design, and a result of our controlling for differences between students with more or less exposure to university, we discovered a pattern of differences and similarities in skill levels between Lower-Level and Upper-Level students. With notable exceptions, Upper-Level students tend to have meaningfully higher skills than Lower-Level students. Taking university courses positively effects student

perceptions of their skill development and actual measured performance in skill areas including: academic research skills as a whole and specific skills including question development, accessing relevant information, summarizing a research paper and self-assessing performance. These improvements reinforce the "standard" wisdom that taking university courses increases academic skills and abilities in at least some areas. On the other hand, attending university seems to have little to no effect in improving student's abilities in oral presentations, critical reasoning, participatory learning, or in critical thinking and research planning. Most instructors would expect to see general progress in student skill levels, so the areas in which no effect was found are disturbing. We cannot easily generalize beyond our particular university context; but it is notable that the skills which showed little or no development tend to be those which are assumed to be *naturally* developed in most university programs – those related to critical thinking, oral communication, and collaborative or independent learning. This study suggests that these assumptions cannot be taken for granted.

### **A Single Semester Inquiry Course Can Have Meaningful Effects on Skill Development**

This study demonstrates that the positive effects associated with taking Inquiry 1SS3 are significant. As the effects of the course are less obvious with the passage of time, the short term effects associated with the seminar can be most clearly seen by considering just Lower-Level students. Amongst this moiety, Inquiry students - those who on average had taken the course within two years of testing - there are widespread and meaningful advantages over the Lower-Level comparison Non-Inquiry students in most of the skill areas we directly tested.

Lower Level Inquiry students perceived themselves to be more self-directed and less guided by others in their learning, and had a higher appraisal of their skill development than the Comparison group. Lower Level Inquiry students scored higher than the Comparison group in the academic research skills exercise rated as a whole and in many of the component skills including accessing relevant information, summarizing a research paper, planning research and self-assessing performance. Lower Level Inquiry students also performed better in oral presentations and in the skills related to the critical reasoning exercise. There were several areas in which Lower Level Inquiry students were no different than the Comparison group including question development, critical thinking, and teamwork. However, it should be emphasized that among Lower-Level students, Non-Inquiry students were never at an advantage over Inquiry students, with the single exception that they offered more and better justifications for their research questions.

**Figure 3:** Typical Pattern, exemplified by Holistic Rating of Academic Research Skills

### Skills, Once Developed, Are Typically Lasting

The situation becomes more complex when Upper Level students are added back into the mix and we look at effects related to a course taken between three and five years previously. Considering for the moment only Inquiry student scores, and comparing Lower and Upper levels, there are examples of both continued skill development and, in a few cases, skill loss. However, in sum the evidence indicates that the skills gained by students who took Inquiry 1SS3 are at least maintained between Lower and Upper Levels.

Though the Inquiry student skills are lasting, the *advantage* they have over the Comparison group typically becomes less pronounced or disappears over time. This is not true in all cases but the pattern is common enough that we regard it as typical (see Figure 3). Inquiry students who have more recently taken the seminar have a clear advantage over the comparisons but with the passage of time do not progress as quickly as the comparisons.

We are unable to fully explain this pattern. One possibility is that there are skills ceilings which Inquiry students simply reach earlier through seminar participation. The ceilings could relate to either student capacity or to 'performance expectation' determined by the demands of the university environment such that once a student has sufficiently mastered a skill set to meet the expectation of the environmental demands, there is little incentive for further progress. The fact that skills do not typically develop further nor dissipate among Inquiry students between lower and upper levels may suggest that the university environment is supportive enough to maintain the skills developed in Inquiry 1SS3 but not challenging enough to stimulate their further development. The relationship of skill ceilings to the supportiveness or challenge of the learning environment remains an important question for further inquiry.

### Conclusions

The logic model (Astin, 1991, 1993) underlying this research assumes that a learning environment is a *complex* system in which many input and environment variables can potentially affect the (output) development of students' skills. While it is impossible to control for all confounding effects (for example, the differences between instructors' style of teaching) or to know the way those effects interact, it is possible to make reasonable connections between the inputs, environment and outputs based on evidence provided by this study.

Important questions about the potency of an Inquiry seminar are addressed by this research. The study supports the idea that it is possible to meaningfully develop academic and intellectual skills with a single first-year inquiry seminar course. The findings suggest that a little intervention (a three unit course) can have relatively large effects. For example, in many cases where 1SS3 is associated with higher performance, the magnitude and significance of the difference is similar to the difference between Lower and Upper-Level students, roughly a two year advantage.

The results outlined here have significant implications for the way universities organize and develop their curriculum, especially for first-year students. These findings suggest that offering a first-year inquiry seminar can be a useful activity for students and the university. At the same time we need to know more about the relative importance of courses that focus on the development of academic skills *per se* versus those that embed skill development in an engaging pedagogy such as inquiry-based learning.

On the other hand, both direct efforts at teaching skills and the cumulative effects of attending university had little or no effect on performance measures of *critical thinking*, *question development*, and *research planning*. As van Gelder (2005) points out "almost everyone agrees that one of the main goals of education, at whatever level, is to help develop general thinking skills, particularly critical thinking skills." Our findings suggest that our university specifically, and other universities by extension, are failing at this task. This introduces a considerable challenge to universities. What steps must they take if they are in improving the abilities of students regarding critical thinking, question development and research planning?

These are of course, complex abilities that, like a second language, require more than a single course or an overall environment supportive of these skill areas. This leads us to believe that more sustained attention needs to be paid to these skill sets throughout university curricula. If we expect students to be life-long learners, universities will need to commit the time and resources to supporting this goal. We hypothesize that extension of inquiry style courses oriented to supporting and challenging the further development of academic and intellectual skills throughout the curricula would ensure universities do in fact produce life-long learners and inquirers.

It is also worthy of note that our findings indicate that measuring skills directly is more sensitive than collecting data from self reports, suggesting that students may not be fully aware of the skills they have developed. The inquiry seminar described in this paper both raised skill levels and awareness of skill levels. The literature suggests that raising awareness of skills is important in facilitating their adaptation to different learning situations (Shepherd, 2000) which we believe is an important aspect of lifelong learning. It may be that one of the important things university can do is make students self-aware of the skills they possess, both the ones they come with and those they develop while at university. These changes would provide students with a heightened awareness of the value of a university education and motivation to continue the process of life-long learning.

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