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**On the Struggle to Attain Universal Competence in a  
Complex Skill: The Case of a Senior Capstone Experience**

Gregory Lilly

Thomas Tiemann

Elon University

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2075 Campus Box

Elon, NC 27244

Phone: (336) 278-5951

Fax: (336) 278-5952

## **Abstract**

Seventeen years ago, a blue-ribbon committee of economists asserted that the “ideal” program for an economics major should include “a capstone experience, whereby students apply their knowledge and skills in creative and systematic ways through research and writing.” (Seigfried, Bartlett, Hansen, Kelley, McCloskey, and Tietenberg (1991)) Yet we are not aware of a data-driven assessment of an implemented senior capstone experience in the economics education literature. We have been experimenting with a senior capstone experience – based on research and writing – for more than a decade. In this paper we describe the history of our senior capstone experience, and provide a data-driven assessment of student performance in this experience. Our primary objective for this senior capstone has been to create a system that will result in all of our majors writing a competent senior thesis. In other words, we want to attain universal competence in a complex skill. This simple objective has, however, been very difficult to achieve. We will argue that undesired variation in student motivation has been our primary obstacle in attaining universal competence.

**JEL Codes: A22**

**Keywords: Senior experience, Capstone**

## **ON THE STRUGGLE TO ATTAIN UNIVERSAL COMPETENCE IN A COMPLEX SKILL: THE CASE OF A SENIOR CAPSTONE EXPERIENCE**

While one of us spent this past spring semester in Poland, teaching at the University of Krakow, and experiencing a different set of challenges; the other was entrenched in a very familiar environment, teaching two sections of “Statistics for Decision-Making” to a total of sixty-eight students, and a section of “Intermediate Microeconomic Theory” to a total of thirty-nine students. Almost all of these one hundred and seven students were young, affluent American undergraduates. And though much of the day-to-day activity in both the statistics and micro classes was probably quite similar to what goes on in any modern American economics department, there were some important differences. The most heavily weighted graded assignment in both courses was to produce an original piece of student research that we term a “coherent argument.” This was not a personal choice by the faculty member; all those who teach in this department make a similar commitment. In order to get our senior economics majors ready for their senior theses, all of them write a series of coherent arguments as they progress through the economics curriculum. Not only do the students in these courses (many of them not economics majors) put in significant amounts of time and effort to complete these coherent arguments, faculty in our department devote significant amounts of time and effort to planning, discussing, mentoring, and assessing these coherent arguments. At the end of each semester, knee-deep in often mediocre student papers, we often ask ourselves this question: “Why do we do this?” After wallowing in the requisite amount of self-pity, eventually we end up telling ourselves that we are doing right thing, given our ultimate goal of teaching all of our majors “to think like economists.” We have an obligation to do all we can to make sure that no economics major “is left behind.”

But are we really doing the right thing? In this paper we will address one specific aspect of that general question: After all we go through, does each one of our graduating majors end up writing a competent senior thesis? If so we have attained universal competence in a complex skill, no economics major has been left behind. To our surprise, we have discovered that attaining universal competence with respect to our senior theses has proven impossible, thus far. Describing that discovery, and speculating as to its cause, is the primary objective of this paper.

To those familiar with the *No Child Left Behind* reform movement in K-12 American public schools, our failure may seem perfectly predictable. As Rothstein (2007) notes, in the face of the significant socioeconomic and cognitive variability that exists in American society, an educational policy based on universal competency is doomed to fail, if the standard is challenging enough. But our environment is quite different from the environment that is bringing down *No Child Left Behind*. Most of our students come from privileged backgrounds, and all are bright enough to make it into a fairly selective college. Our faculty is talented and energetic, we apply relevant assessment practices, and our teaching resources are almost extravagant. Yet we have unable to achieve universal competence, why?

We begin, in Section (I), by briefly outlining our teaching philosophy. Our focus in this paper is the senior capstone experience, so in the first part of Section (II) we explain the structure of our current senior capstone experience. Many facets of our current senior capstone experiences are the result of trouble-shooting on our part; hence in the second part of Section (II) we describe

how our structure evolved over time. Section (III) contains an assessment of our progress toward our goal of universal competence. As we have already admitted, we have been surprised by how difficult it has been to achieve progress. We have a theory as to why we have struggled to progress toward universal competence, and our theory is found in Section (IV). We suspect that the production of majors who can think like economists is best modeled as a fixed-proportion technology, and one of the necessary inputs is quite expensive in terms of the time and effort required to acquire it. What is this necessary input? It appears *not* to be student intelligence (as measured by SAT scores), but rather student motivation.

### **(I) OUR TEACHING PHILOSOPHY**

Seventeen years ago, a blue-ribbon committee of economists, deeply committed to teaching, published a report that contained an evaluation of the American undergraduate economics major (Siegfried, et al. [1991]). The committee argued that "... the quality of the major is suboptimal." (ibid, p.20); and gave the economics major, circa 1990, a "B-". The committee then proposed some recommendations that they thought could potentially improve the economics major. At the time our department was dissatisfied with its curriculum and pedagogy, thus we thought deeply about the committee's analysis and recommendations. We noted, in particular, the following three goals.

**G1** "Enabling students to develop a capacity to "think like an economist" is the overarching goal of the major. All other virtues follow." (p. 21)

**G2** "An ideal program for the major includes ... a capstone experience, whereby students apply their knowledge and skills in creative and systematic ways through research and writing." (p. 21)

**G3** "... [S]tudents should be in classes sufficiently small to permit them to interact effectively with their instructors. Professors should then be expected to employ evaluation methods that give students an opportunity to develop and use writing and oral skills. Learning should take a more active form, and therefore have longer lasting effects. (p. 25)

These three goals resonated with the department back then, and soon afterwards we embarked on a journey to develop an economics major that was based on the Siegfried committee goals presented above: **G1**, **G2**, and **G3**.

Over the years, department members and administrators have come and gone, the size of the department has grown (in terms of both majors and faculty), and our college ethos has changed from one that was obsessed with teaching (hence almost hostile toward research) to one that embraces research. Yet through it all, our department is still driven to achieve **G1**, **G2**, and **G3**. We want to teach our majors how "to think like an economist," we want to offer a serious capstone experience to our majors so that they can engage in creative research, and the classroom experience ought to be marked by student engagement and active learning. In this paper we only have time to discuss our senior capstone experience.

## ***(II) OUR SENIOR CAPSTONE EXPERIENCE***

We suspect there are many, equally valid, methods of implementing a senior capstone experience; see, for example, Elliot, Meisel, & Richards (1998) and Elliot (2004). There is nothing particularly special about our approach; all we wanted our majors to do in their senior capstone experience was to engage in some serious and relatively independent research having

something to do with economics. However we discovered, early on, that stepping back and simply telling our seniors to engage in serious research was a recipe for mediocre results. We hypothesized that through the creation of a more structured process for our senior's research projects, we would see higher quality from our students. And that is what we have been doing ever since, over time adding more structure to our senior capstone experience.

This section is divided into three subsections. In the first subsection we will present a brief overview of our whole system as it stands today. The fundamental idea in our senior capstone experience – the coherent argument – is explained in the second subsection. And in the third subsection, we describe how our current senior capstone experience evolved over time.

### **(A) The Current System**

In terms of coursework, our major is pretty traditional. Courses in our department fall into one of four levels: 100-level (no prerequisites, and meant mostly for freshmen), 200-level (small number of prerequisites), 300-level (more prerequisites, enrollment is primarily juniors, there are some seniors), and 400-level (many prerequisites, enrollment is primarily seniors). Our department is located in a business school that also offers an accounting major, and a business major; not surprisingly, these majors are much more popular than the economics major. Much of our teaching, therefore, occurs in economics courses that business and accounting majors are required to take: Principles of Economics, Statistics, and Business Economics. Almost all of our courses are “4-hour” courses which is the standard for our campus. And with respect to our 300-

level courses – the level where most of our courses are - the course can be “light,” “medium,” or “heavy” in terms of the proportion of the class that are economics majors.

In order to major in economics, a student is required to take a calculus course and an elementary statistics course from the mathematics department that is a prerequisite for the statistics course we offer. Principles, our statistics course, intermediate macro, intermediate micro, one 400-level course, and four elective courses (either 300-level or 400-level) are required. The final requirement for an economics major is our senior capstone experience. Currently this experience consists of each senior major creating an original coherent argument in economics during their senior year. Right now this task (coherent argument creation) is divided into a fall semester experience: a “2-hour” class taught by an instructor from the department, and a spring semester experience (which also counts for “2-hours”) that is more like an independent study in that there is no instructor, no classroom meetings, no textbook; instead each student’s research and writing is mentored by one department member.<sup>1</sup> For further details concerning our current senior capstone experience, explore this link:

<http://www.elon.edu/e-web/academics/business/economics/senior.xhtml>.

### **(B) The Product: Coherent Arguments**

In this subsection we will explain the structure of the paper that each senior major turns in at the conclusion of their senior year. As noted above, we call this paper a “coherent argument,” and all we are trying to do with this coherent argument idea is capture the key elements of an ordinary

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<sup>1</sup> No faculty member can have more than three seniors to mentor each year.



research paper that one would find in an ordinary professional journal in economics.<sup>2</sup> The components of a coherent argument are: *Initial Claim*, *Theory*, *Empirical Evaluation*, *Backing*, and *Revised Claim & Summary*. We will now attempt to explain the meaning and purpose of these components, and show how they can fit together to create a powerful and persuasive argument.

The construction of a coherent argument is a process that is sparked by an *Initial Claim*. An *Initial Claim (IC)* can be any statement with an unknown truth-value that economists would find interesting. The desire to uncover the *IC*'s truth-value leads to research: the creation of an elaborate system of interrelated statements that will either confirm or falsify the *IC*. In our conception of economics the truth-values of all initial claims should ultimately depend upon the characteristics of some set of data. Since data must be the arbiter in any disagreement in economics, we assume that the term “data” refers to anything that could be reliably sensed (seen, heard, touched, etc.) by multiple observers under certain conditions.

In one respect both the *Theory* and the *Empirical Evaluation* are simply choices as to how to “read” the data. One *Theory* differs from another in utilized concepts and categories. When one chooses a particular *Theory (T)*, a particular set of concepts and categories becomes salient, and certain data characteristics become relevant. One could say similar things about the *Empirical Evaluation (EE)*. *EEs* differ in their utilized concepts, categories, and procedures; and when one chooses a particular *EE*, a particular set of concepts, categories, and procedures becomes salient,

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<sup>2</sup> The original inspiration for the “coherent argument” comes from Toulmin (1969).

and certain data characteristics become relevant. In another respect both the *T* and the *EE* dramatically increase the ability of the researcher to uncover the *IC*'s truth-value. Given the current state of economics, *Ts* are normally expressed in the languages of logic and mathematics, and *EEs* are normally expressed in the languages of probability and statistics. So a *T*, embedded in logic and mathematics, will often supply a system of formal deduction that can be used to support relationships between the *IC* and other statements. For example, through an application of a *T* to an *IC*, one might prove that the *IC* logically implies another statement which has a much closer connection to the relevant data. Likewise an *EE*, embedded in probability and statistics, will often supply a system of formal induction that can be used to support relationships between the *IC* and other statements. For example, as a result of an *EE* the *IC* might be transformed into a confidence interval for a population parameter.

The *IC*, the *T*, and the *EE* are all choices made by the researcher. However a researcher needs to answer this question: "Why these choices, and not others?" In a coherent argument there must be reasons for making a choice; these justifications are found in the *Backing (B)*. In addition, chosen *ICs*, *Ts*, and *EEs* almost always have histories. What have previous economists learned about these *ICs*, *Ts*, and *EEs*? Where are the dead ends? What paths appear promising? Answers to questions such as these are also found in the *B*.

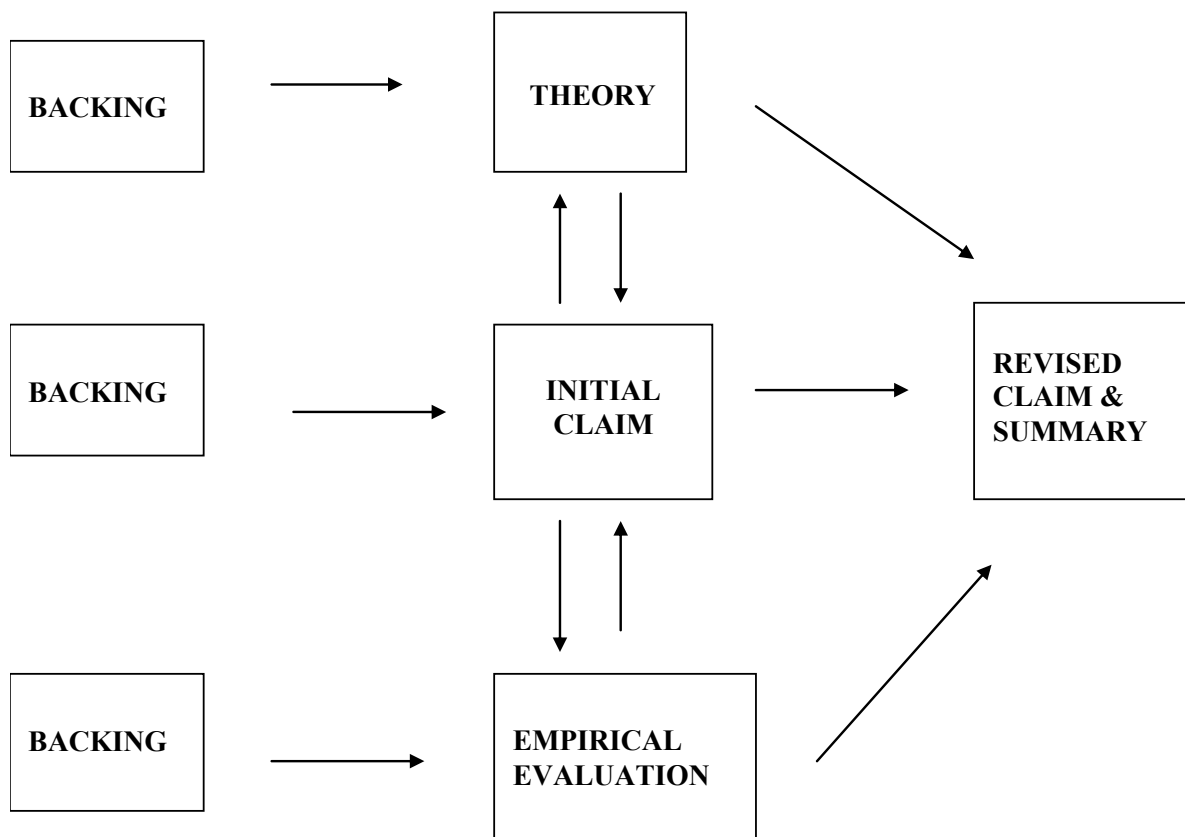
Finally we discuss the last component: the *Revised Claim & Summary (RC&S)*. When the research is over, and the researcher reflects upon what has happened, inevitably some new and unexpected aspect of the *IC* ends up being discovered; in other words, the *IC* ends up being

revised. And when the researcher completes the argument by: (a) outlining the key points in the argument, (b) reaching a conclusion with respect to the *IC*'s truth-value, (c) explaining how the research process lead to the discovery of a revised claim, and (d) pondering the significance of the revised claim, she has produced a (*RC&S*).

Below is an attempt to visually depict a coherent argument, see Figure 1.

**Figure 1**

**Coherent Arguments: The Process & Components**



What do the arrows in Figure 1 signify? The arrows suggest direction of support. For example looking at the left of Figure 1, the *B* can support the choices of *IC*, *T*, and *EE*. Now notice the middle of Figure 1; *T*, *IC*, and *EE* support one another, and are supported by one another. In a good argument, a *T* is chosen because it is appropriate given the nature of the *IC*. Likewise, an *IC* will interest more economists if a valued *T* can be productively applied to it. Obviously the previous two statements can also be written with *EE* replacing *T*. Finally on the right of Figure 1, in a good argument the *RC&S* has to be supported by the *T*, *IC*, and *EE*; which implies that *B* supports *RC&S*.

Consider what a student must do to succeed at coherent argument construction. The student must be able to choose among *ICs*, *Ts*, and *EEs*, explore the economics literature in order to justify those choices (thereby creating a *B*), develop logical connections between these components, discover something original concerning the chosen *IC*, and then step back and identify the structure and shortcomings of the overall argument (thereby creating a *RC&S*). This is an unstructured and difficult problem, even for a senior major. None of these tasks alone, much less this combination of tasks, can be accomplished by applying a problem solving template or mimicking an argument found in class notes or in a textbook. Producing a competent coherent argument is therefore a complex skill.

### **(C) The Evolution of our Current Senior Capstone Experience**

For twelve years we have been experimenting with different versions of a senior capstone experience. Early on we made the fortunate decision to agree upon an admittedly imperfect measure of coherent argument quality, and each year we, as a department, have invested the time and effort to measure the quality of our seniors' coherent arguments.<sup>3</sup> And thanks to this data we have been able to maintain, over the years, a Shewhart cycle of “plan, do, study, and act” with respect to our senior capstone experience. We offer the following four themes as a way of understanding our journey.

### ***Theme 1: Private to Public and Autonomy to Constraint***

We began to require senior theses in AY 1995-6.<sup>4</sup> Initially the production of these theses was a rather private affair. In the spring semester of their senior year the student signed up for a generic 2-hour independent study course, and picked one department member as her advisor. The advisor, with minimum input from the department, created the paper requirements, mentored the research, and graded the final paper. While a system with this much faculty autonomy was easy to get off the ground, most of us were dissatisfied with the process and results. Yet, since everything was private, poor performance by both senior and mentor could easily be hidden. Around AY 1997-8, the department decided to set aside one Friday afternoon late in the spring semester, and force the seniors to orally present their theses. Every senior and every department member were required to attend. As we recall, the idea of public presentations was not driven by a goal of improved student performance. At the time we viewed the public presentations as more of a social event, a way for the faculty to bond a little more with the seniors and “celebrate” the

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<sup>3</sup> Details concerning the measurement process are found below.

<sup>4</sup> The term “AY 1995-6” denotes the academic year that began in the fall of 1995, and ended in the spring of 1996.

research that we had accomplished together. But this “celebration” had two serendipitously important impacts on the evolution of our senior capstone experience. First of all, once the senior and mentor performance became public; the wide variation in quality became public. Secondly, we also noticed an important new motivator (shame and embarrassment) that could be exploited to improve the senior theses; after all, who among the students and the faculty wants to look bad in front of their peers?

So we quickly learned two lessons. One, making the senior capstone experience as public as possible increases average quality since the motivation of avoiding shame and embarrassment can sometimes offset a diminished level of curiosity, or offset the attraction of another pursuit. Two, allowing the senior and mentor to have the freedom to negotiate the thesis’ requirements and evaluation is a significant factor generating quality differences. Reducing this factor was the spur compelling us to develop and systemize the idea that our senior thesis *equals* the production of a coherent argument. By AY 1999-2000 we had a prototype coherent argument definition and scoring guide, and we began to formally assess senior performance on their theses. Every full-time faculty member in the department agreed to use the scoring guide and grade each senior thesis. In addition, we met as a department to discuss the resulting data. By AY 2000-1 we were working with the coherent argument definition and scoring guide found in this paper; and in every year from AY 2000-1 to AY 2005-6, each full-time faculty member used the scoring guide (see Appendix 1) to grade each senior thesis. In addition, each year during this period the department met at least two times to discuss senior thesis matters. Before we used the scoring guide to grade the latest batch of senior theses, we would conduct a calibration session in our first meeting. In such a session we would take a past senior thesis and grade it again using the

scoring guide, we would then discuss our choices of scores for the various coherent argument components (*IC, B, T, EE, and RC&S*). In our second meeting, after the latest batch of senior theses had been scored, we would get together to discuss the results and plan revisions and experiments.

Over the years the number of our majors slowly began to grow, and by AY 2005-6 it had become rather burdensome for each faculty member to grade each senior thesis. In AY 2006-7 we decided to create a slightly different scoring system; and now only three faculty members grade a senior thesis: the senior's mentor plus two other randomly chosen faculty members. Nothing else has changed though. We still use the same scoring guide, and we still meet two times a year to first calibrate and then discuss the senior thesis results.

### ***Theme 2: Moving From Independence and Mentoring to Classroom Instruction***

Though our current senior capstone experience contains a required 2-hour class, with instructor and textbook, which meets weekly during the fall semester; this class is a relatively new addition.<sup>5</sup> In the first few years of our senior capstone experience we would simply meet with all the seniors early in the fall semester, and give them a "Senior Handbook" that described our idea of a coherent argument, contained the scoring guide, and listed the important due dates: the oral proposal presentation date, the final paper presentation date, and the final paper date. We then, in the meeting, tried our best to persuade the seniors that it was in their interest to begin working on their senior thesis as soon as possible. The first step, we would tell them, was to find a willing

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<sup>5</sup> The textbook we have been using in this class is Greenlaw (2006).

mentor for your thesis. We then hoped that the mentors would begin, as soon as possible, to tutor the seniors on the mechanics of economics research. Those seniors who: (a) were strongly motivated, (b) had that extra level of curiosity, and (c) already had a good relationship with a faculty member, tended to thrive in this unstructured process; those seniors who could not satisfy these three conditions, struggled to various degrees.

Siegfried (2001) noticed that in Vanderbilt's undergraduate honors program in economics, identifying a "good" thesis question was usually the "major hurdle for most students" writing an honors' thesis (ibid, p.175). Obviously a trite thesis question will not support original thinking and creative contributions. In order to level the playing field and increase the overall quality level of the senior theses, we decided to offer a fall workshop that senior majors could take to get them ready to do serious and independent economics research by helping them to identify "good" thesis questions. The first one took place in AY 2003-4. It was 2-hour course; and not every senior enrolled since it was not required at the time. The course had no textbook, and we really had no model to follow. We were not sure about what we should try to do; or how we should go about it. We just did it.

This past fall (AY 2007-8) we taught this fall senior seminar for the fourth year in row. As we have already mentioned, it has become a required course, we now have text, and we now (given our experience) have a better idea of what we should do in the class, and how we should do it.



### ***Theme 3: Fighting Procrastination by Pushing up Deadlines***<sup>6</sup>

In the beginning (AY 2000-1), our seniors were encouraged to begin thinking about their theses in the fall semester of their senior year, but the only formal deadline they had to meet involved presenting and defending an oral proposal in front of the faculty and their fellow seniors during the second week in February, about two and a half months before their thesis was due. It was clear, given our observations, that many of the students were not really doing any serious work on their thesis until January. After turning in their work, several of these students confessed that they had run out of time due to their natural procrastination which in past (non-senior thesis) assignments had gone unpunished in terms of lower grades. In order to fight this problem (which is deadly for a senior thesis), the next year we pushed up the oral proposal presentation date to the first week in December. And though the oral proposal presentation date remains the first week in December, we have used the fall senior capstone course as another way to control procrastination. In fact, this year's instructor of the fall course put intense pressure on the seniors to get serious on the first day of her class.

### ***Theme 4: Gaining Experience through Research across the Curriculum***

The most costly method we have applied as we try to increase the overall level of senior thesis quality is to make our majors practice coherent argument construction before they become seniors. That might seem a little ridiculous. After all, you can only do a senior thesis once. Besides, it is absurd to think that a freshman or sophomore in Principles of Economics is ready to tackle the kind of coherent argument that we described above. Both points are apropos; but one

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<sup>6</sup> This is another issue discussed in Seigfried (2001).

can create assignments that call for simpler coherent arguments, and have students practice on these simpler coherent arguments. And that’s what we have done over the years. Below, in Table 1 we describe how we have taken our idea of a coherent argument and adapted them to fit the different levels of our curriculum so that our majors can do coherent argument construction at a reasonable level of challenge.

**Table 1: Acquiring Experience with Coherent Arguments**

<p><i>CAs in Principles (100-level):</i></p> <p>Create research paper assignments that only comprise of <i>IC</i>, <i>T</i>, and <i>EE</i>. Instead of requiring that the <i>IC</i> interest an economist, either assign the <i>IC</i>, or allow the student to pick the <i>IC</i> on the basis of their interest. In terms of the <i>T</i>, ask the student to pull it out of the textbook. Allow the <i>EE</i> to be descriptive and informal.</p>
<p><i>CAs in Statistics (200-level):</i></p> <p>Create research paper assignments that only comprise of <i>IC</i>, <i>T</i>, and <i>EE</i>. Allow the <i>IC</i> and the <i>T</i> to be outside of economics. The <i>EE</i>, on the other has to be more sophisticated than a 100-level coherent argument; the <i>EE</i> needs to be inferential in character.</p>
<p><i>CAs in Intermediate Macro, Intermediate Micro, and other 300-level courses with a medium to heavy proportion of economics majors:</i></p> <p>Create research paper assignments that comprise of <i>IC</i>, <i>T</i>, <i>EE</i>, and begin to bring in <i>B</i>. Help the students discover relevant previous work by economists, and locate appropriate professional journal articles that will provide good backing. The <i>IC</i> needs to be economically interesting, and while the <i>T</i> may come from the course textbook, the <i>Ts</i> at this level must be more sophisticated than the <i>Ts</i> at the previous two levels. The <i>EE</i> needs to be inferential and multivariate in character.</p>
<p><i>CAs in the 400-level courses:</i></p> <p>Create research papers that are full-blown CAs (see Figure 1). Expect each component (<i>IC</i>, <i>T</i>, <i>EE</i>, <i>B</i>, and <i>RC&amp;S</i>) to be competent (see Appendix 1). The only difference between 400-level CAs and a senior thesis is that the <i>IC</i> in a 400-level CAs must be related to the subject matter of the course.</p>

There are three important things to note about Table 1. One, it is hard work to coordinate an approach like you see in Table 1; everyone in the department (including adjuncts) needs to buy into it, and everybody needs to work together so that students see and understand the connections that the faculty are trying to make.<sup>7</sup> Two, the 400-level in our curriculum did not even exist when we started gathering public data on the quality of the senior theses (AY 1999-2000). Only after we noticed how poorly our seniors were doing on the *Theory* component of their theses, did we come up with the idea of 400-level courses; whose primary characteristics are: (a) prerequisites of intermediate micro and macro, (b) reading lists containing professional journal articles, and (c) the expectation that teaching and learning relatively sophisticated theory would be an important component of the course. And it was not until AY 2002-3, that a 400-level course became an economics major requirement. Three, it has taken us even longer to re-design the flow of our curriculum so that we can get most of our majors to take a 400-level course before the spring semester of their senior year. If our majors are only able to take their 400-level at the same time they're writing their senior theses (spring semester of their senior year), then the 400-level course is not serving its intended purpose. Only in the last year or two, once again through curriculum changes, have we begun to get most of our majors through their 400-level course before the spring semester of their senior year.

### ***(III) ASSESSING OUR PROGRESS TOWARD UNIVERSAL COMPETENCE***

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<sup>7</sup> For example, a teacher may require a research paper, but – understandably – may frame and discuss it in a terminology that the faculty member is comfortable with rather than the coherent argument terminology. As a result the student may not process their work as “coherent argument practice.”

So have all of these years of putting in the effort to maintain a Shewhart Cycle paid off? Has performance in our senior capstone experience improved? In this section we will first adopt a simple production function and use it to model student performance, as well as to model the changes described in Section (II). We will then test the model's prediction against the data we have on our senior thesis quality. In testing the prediction we will apply data coming from these three years: (a) AY 2000-1 (the first use of our current scoring guide), (b) AY 2007-8 (our latest results), and (c) AY 2004-5 (an arbitrary year in between the beginning and end).<sup>8</sup> These three years of data are sufficient to show our main result: a failure to improve overall senior thesis performance. We are not moving toward universal competence.

### **(A) The Prediction**

Consider the following Cobb-Douglas production function:

$$(1) Q(t) = \alpha * X(t)^\beta * Y(t)^\gamma.^9$$

The plan is to use (1) to model the behavior of a class of senior majors; hence the variables in (1) denote various measures of center. Suppose  $Q(t)$  represents the output: overall (or average) student performance, at year  $t$ , on the coherent arguments in our senior theses. Suppose  $X(t)$  and  $Y(t)$  represent two different types of input;  $X(t)$  represents the average amount, at  $t$ , of a certain set of learning inputs that can be controlled by the faculty, and  $Y(t)$  represents the average amount, at  $t$ , of certain set of learning inputs (observed and unobserved) that we believe are not

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<sup>8</sup> The results in AY 2004-5 have the same basic patterns as the other years in between the beginning and end.

<sup>9</sup> The key characteristic of this production function, given our purposes, is that the two inputs are imperfect substitutes for one another.

subject to control by the faculty. The Greek letters:  $\alpha$ ,  $\beta$ , and  $\gamma$  are all parameters that are greater than zero.

Three of our themes, in Section (II), concerned controllable learning inputs. Under **Theme 2** we discussed the AY 2003-4 creation of the 2-hour fall semester course for our senior majors, and how the design and execution of this course has improved over time. If the term: *Instruction* ( $t$ ) represents the average amount of formal instruction that seniors, at  $t$ , have had in the creation of senior theses; then *Instruction* ( $t$ ) is one component of  $X(t)$ . And we believe that:

$$(2) \textit{Instruction}(\text{AY } 2000 - 1) < \textit{Instruction}(\text{AY } 2004 - 5) < \textit{Instruction}(\text{AY } 2007 - 8)$$

Under **Theme 3** we discussed our tendency, over time, to coerce our seniors into ever earlier starting times for their theses. If the term: *Time* ( $t$ ) represents the average amount of time that seniors, at  $t$ , devoted to their senior theses; then *Time* ( $t$ ) is another component of  $X(t)$ . And we believe that:

$$(3) \textit{Time}(\text{AY } 2000 - 1) < \textit{Time}(\text{AY } 2004 - 5) < \textit{Time}(\text{AY } 2007 - 8)$$

Finally, under **Theme 4** we discussed our practice schedule (see Table 1) for senior theses. If the term: *Experience* ( $t$ ) represents the average amount of experience that seniors, at  $t$ , have with creating coherent arguments; then *Experience* ( $t$ ) is another component of  $X(t)$ . And we believe, given the relatively late introduction of our 400-level courses and the time it has taken us to fully implement a system like the one described in Table 1, that:

$$(4) \textit{Experience}(\text{AY } 2000 - 1) < \textit{Experience}(\text{AY } 2004 - 5) < \textit{Experience}(\text{AY } 2007 - 8)$$

So in summary, let's assume:

$$(5) \mathbf{X}(t) = (\mathit{Time}(t), \mathit{Experience}(t), \mathit{Instruction}(t)).$$

And we believe, given: (2), (3), and (4) that:

$$(6) \mathbf{X}(\mathit{AY} 2000 - 1) < \mathbf{X}(\mathit{AY} 2004 - 5) < \mathbf{X}(\mathit{AY} 2007 - 8).$$

We also presume that, on average, the amounts of the uncontrolled learning inputs have not changed over the years:

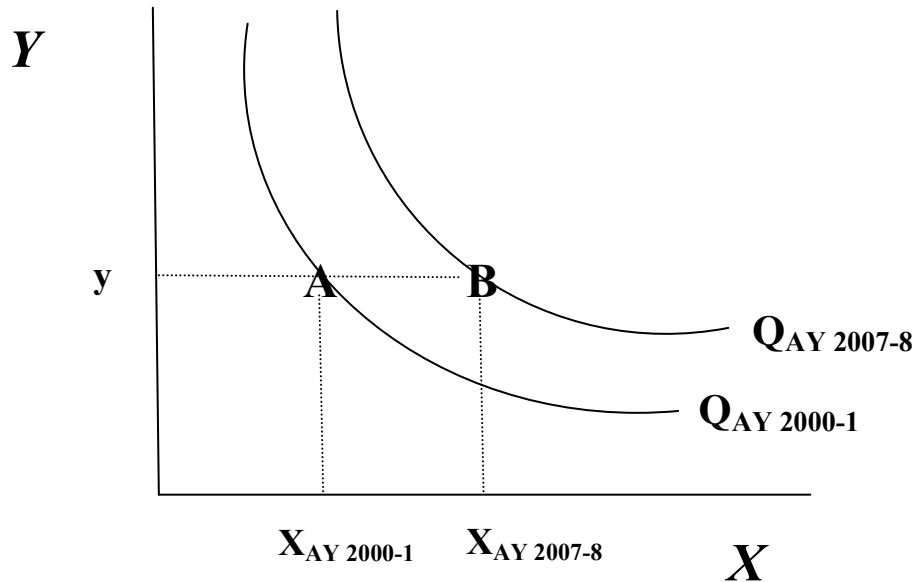
$$(7) \mathbf{Y}(\mathit{AY} 2000 - 1) \cong \mathbf{Y}(\mathit{AY} 2004 - 5) \cong \mathbf{Y}(\mathit{AY} 2007 - 8).$$

We therefore predict, given (1) that:

$$(8) \mathbf{Q}(\mathit{AY} 2000 - 1) < \mathbf{Q}(\mathit{AY} 2004 - 5) < \mathbf{Q}(\mathit{AY} 2007 - 8).$$

Or in terms of a visual depiction, our prediction is captured by Figure 2 below.

Figure 2



Assuming the strictly convex isoquants associated with a production function like (1); if (6) and (7) are true, then we predict that, on average, our seniors moved from point **A** to point **B**; in other words, (8) must be true.

### (B) Testing the Prediction

In order to test (8) we need a measure of the overall level of senior thesis performance. Therefore consider a measure we have developed that we call the *Competency Rating*. Initially each senior project was scored by each department member according to our scoring guide (see Appendix 1). Thus for every senior there was an assigned number, from every scorer, for each of the five coherent argument components (*IC*, *B*, *T*, *EE*, and *RC&S*) plus one assigned number representing the “overall quality” of the coherent argument. Initially, we agreed to use a “1” to denote a

coherent argument component rated as “Poor,” to use a “5” to denote a component as “Competent,” and a “10” to denote a component rated as “Excellent.” So, a score between 5 and 10 denoted a coherent argument component that was a mix of “Competent” and “Excellent.” More recently, we have used a more compact scoring continuum (“1” for “Poor,” “3” for “Competent,” and “5” for “Excellent”); and as noted above, no longer is every senior project graded by every department member. Nevertheless, if in a given year there are  $n$  seniors and  $m$  department members grading senior projects, we will have  $(6*n*m)$  coherent argument component numbers. From this raw data we can then calculate  $(6*n)$  different competency ratings: a measure of how the faculty, in general, judged the competency of each student on the five coherent argument components plus the overall quality ( $OQ$ ) dimension. Formally, the Competency Rating ( $CR_{xy}$ ) for each student  $x$  on each component  $y$  is defined as:

$$CR_{xy} = \frac{\text{(Number of scorers rating student } x \text{ competent on component } y)}{\text{(total number of scorers)}}$$

Obviously this ratio can run from 0 to 1. If a senior receives a  $CR$  of 0 for the *Backing* ( $B$ ) component, then *every* scorer rates this senior’s  $B$  as incompetent since *every* scorer gave this coherent argument a numerical rating of less than 5 (or using the more recent scale, less than 3) after consulting the scoring guide with respect to the  $B$  component. If a senior receives a  $CR$  of 1 for  $B$ , then *every* scorer gave this coherent argument’s  $B$  a numerical rating of 5 or more (or using the more recent scale, 3 or more). Therefore, ratios that are close to 1 signal competence; and ratios that are close to 0 signal incompetence. For example, Table 2 displays the 78 competency ratings for our thirteen AY 2000-1 seniors. The columns display the five coherent argument components, plus overall quality ( $OQ$ ), and the rows display the thirteen seniors



(ordered from best score (top) to worst score (bottom)). Each cell in the matrix contains the appropriate  $CR_{xy}$ . For example,  $CR(x = 12^{\text{th}} \text{ senior}, y = \text{Empirical Evaluation}) = 0.57$ .

**Table 2: Competency Ratings for AY 2000-1**

		CA Components						Senior Median
		IC	B	T	EE	RC&S	OQ	
	1 <sup>st</sup>	1	1	1	1	1	1	1
	2 <sup>nd</sup>	1	1	1	1	1	1	1
	3 <sup>rd</sup>	0.86	1	1	1	1	1	1
	4 <sup>th</sup>	1	1	1	1	0.86	1	1
	5 <sup>th</sup>	1	1	1	1	0.86	1	1
	6 <sup>th</sup>	1	1	1	1	1	0.86	1
<b>Senior</b>	7 <sup>th</sup>	1	1	1	1	1	0.86	1
	8 <sup>th</sup>	0.86	0.71	0.86	1	1	1	0.93
	9 <sup>th</sup>	0.86	0.71	0.57	0.43	0.86	1	0.786
	10 <sup>th</sup>	0.71	0.286	0.286	0.86	0.86	1	0.786
	11 <sup>th</sup>	0.71	0.286	0.57	0.86	0.57	0.86	0.643
	12 <sup>th</sup>	0.57	0.86	0.286	0.57	0.43	0.86	0.57
	13 <sup>th</sup>	0.43	0.71	0.14	0.286	0.57	0.71	0.5
<b>Component Median</b>		0.86	1	1	1	0.86	1	

We had seven department members grading the senior projects in AY 2000-1, so four of them ( $4/7 = .57$ ) rated the twelfth senior competent on *Empirical Evaluation (EE)*.

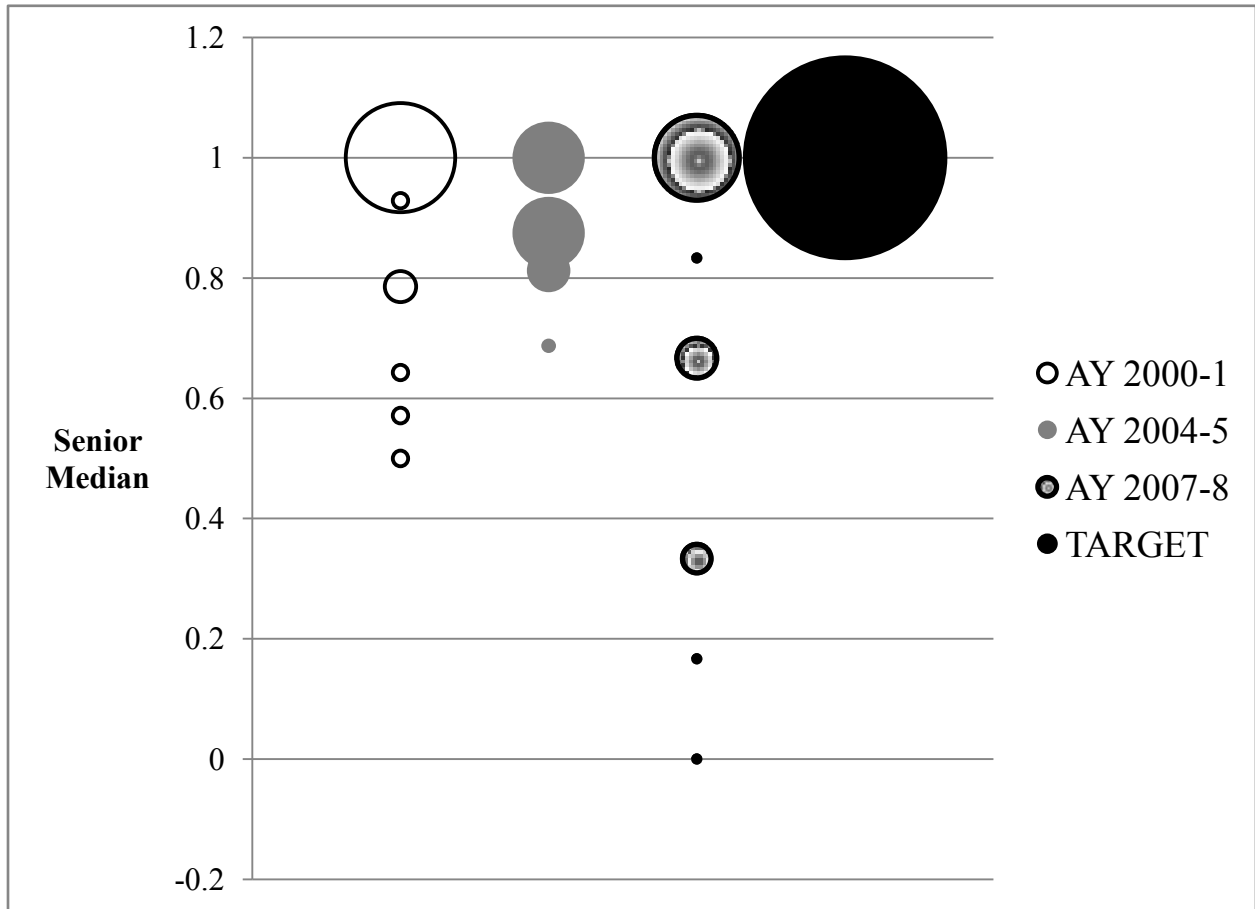
The last column in Table 2 contains a summary measure: the median of the component  $CR$ s for each senior. We will refer to this measure as the “senior median;” and we will use this number to represent the senior’s average performance on their senior thesis. We can now precisely define what we mean by universal competence; we define universal competence at year  $t$  ( $UC(t)$ ) as:

$$UC(t) = \text{All seniors, at } t, \text{ earn a “1” for their senior median.}$$

Satisfying our target of  $UC(t)$  therefore means that all of the seniors that year are judged to be competent by all of the faculty members in a majority of the six components associated with a coherent argument.

In Figure 3 we use a bubble chart that allows a quick comparison of our senior medians across the three years we have chosen to focus on, and against our target. The bubble's width represents the per cent of the senior medians at that particular level. For instance, the big black bubble represents our target: the case where one hundred per cent of our seniors receive a median component  $CR$  of 1. Likewise, the tiny dot in the AY 2007-8 data at the senior median level of zero represents the fact that one out of the eighteen AY 2007-8 seniors received a zero for their median component  $CR$ . Figure 3 clearly indicates that our prediction of improved senior thesis performance is wrong.

Figure 3



Finally we present, in Table 3, the data underlying Figure 3. Table 3 also includes some simple summary statistics which confirm our conclusion that (8) is false.

Table 3: Senior Medians

		AY 2000-1	AY 2004-5	AY 2007-8
		Senior median	Senior median	Senior median
	1 <sup>st</sup>	1	1	1
	2 <sup>nd</sup>	1	1	1
	3 <sup>rd</sup>	1	1	1
	4 <sup>th</sup>	1	1	1

	5 <sup>th</sup>	1	1	1
	6 <sup>th</sup>	1	0.9375	1
<b>Senior</b>	7 <sup>th</sup>	1	0.875	1
	8 <sup>th</sup>	0.93	0.875	1
	9 <sup>th</sup>	0.786	0.875	.833
	10 <sup>th</sup>	0.786	0.875	.667
	11 <sup>th</sup>	0.643	0.875	.667
	12 <sup>th</sup>	0.57	0.8125	.667
	13 <sup>th</sup>	0.5	0.8125	.667
	14 <sup>th</sup>		0.8125	.333
	15 <sup>th</sup>		0.6875	.333
	16 <sup>th</sup>			.333
	17 <sup>th</sup>			.167
	18 <sup>th</sup>			0
	<b>Mean</b>			
	<b>Senior</b>	<b>0.863</b>	<b>0.896</b>	<b>0.704</b>
	<b>Median</b>			
	<b>95%</b>			
	<b>Confidence</b>			
	<b>Interval</b>			
	<b>Lower</b>	<b>0.750</b>	<b>0.844</b>	<b>0.537</b>
	<b>Bound</b>			
	<b>Upper</b>	<b>0.975</b>	<b>0.948</b>	<b>0.871</b>
	<b>Bound</b>			

#### ***(IV) WHAT HAS HAPPENED?***

Despite our struggle (see Section (II)) to achieve universal competence, our data suggests (see Section (III)) that the overall quality level of our senior theses has not moved for eight years. How is this possible? We will mention three possibilities, but only the last possibility – for this particular complex skill, *student learning is best modeled as a fixed proportions technology fundamentally limited by an input that is costly to increase: motivation* - will be pursued in this paper.

### (A) Some Possibilities Ignored for Now

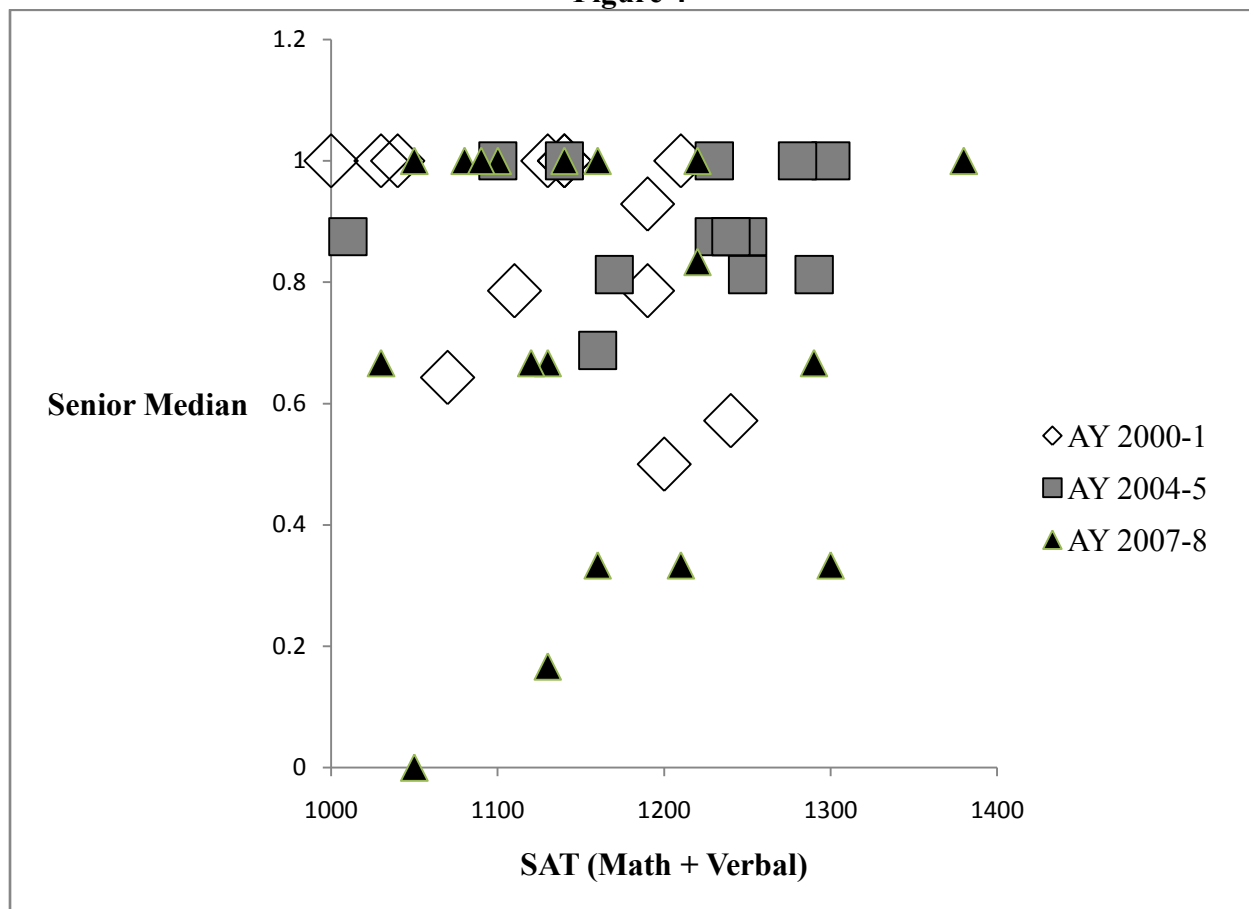
The first possibility is that the set of inputs represented by  $Y$  have decreased over time thereby offsetting the increases in  $X$  that we have created. For example, let's go back to Figure 2. We can represent this prospect by placing a point on the  $Q_{AY\ 2000-1}$  – isoquant right above the point on the x-axis representing  $X_{AY\ 2007-8}$ ; maybe this point is where the department and our seniors found ourselves this past academic year due to a decline in  $Y$ . However, we are somewhat skeptical of this kind of explanation. While we are not sure as to the exact make-up of  $Y$ , our college has become more selective in their admissions over the years. If the general level of  $Y$  in our seniors has been changing, it is more likely that it has been increasing, not decreasing. For example, consider SAT scores, one probable component of  $Y$  in most cases of learning. In Figure 4 we present a scatter plot that displays two patterns: (a) the SAT scores of our senior majors have not been falling over time, and (b) thus far SAT scores have not been positively related to senior medians.<sup>10</sup> Clearly Figure 4 does not disprove a theory that  $Y$  has declined, but perhaps it deepens the mystery as to what comprises  $Y$  in our case. If a widely accepted measure of intelligence does not positively correlate with the coherent argument quality produced by our seniors, what does?<sup>11</sup>

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<sup>10</sup> For these three years, the correlation coefficient associated with SAT and senior median is -0.017.

<sup>11</sup> Frey & Detterman (2004) show that SAT scores are strongly correlated with measures of general cognitive ability. The fact that SAT scores are not positively correlated with our measure of coherent argument quality may raise the issue of whether our measure is valid; but it is important to note that our college, like most, selects on SAT scores. If an admitted student has a “low” SAT, our admissions office believes that the student has other characteristics that predict college success, and these characteristics will offset the “low” SAT. Thus, the insignificant correlation coefficient we report concerning SATs and senior medians does not mean that intelligence is not related to coherent argument quality; we are probably seeing the effect of the statistical problem known as “restriction of range.”

Figure 4



A second possibility that we will simply mention is that there might be some measurement bias in  $\mathcal{Q}$ . One of things our department has noticed in our last few calibration sessions with our scoring guide is a tendency for us to grade past senior theses more harshly now. For further evidence that we may be grading tougher now, consider this. We recently reviewed the five lowest scoring coherent arguments from AY 2000-1 again (the senior medians ranged from 0.5 to 0.786, see Table 4), and noticed that none of the five *EEs* contained a single regression, two of the *Bs* contained only one reference to a professional journal article, and three of the *Bs* contained no references to a professional journal article. On the other hand, in AY 2007-8 we had our first coherent argument to get a senior median of zero, yet the *EE* in this senior thesis

contained four multiple regressions with dummy variables, and the *B* contained references to four different professional journal articles.

Though it would be interesting to further explore this possibility, at the moment all we have right now to work with is relatively weak anecdotal evidence. Besides the weak data, there are other reasons to be skeptical of this measurement bias possibility. Given our current curriculum our seniors now receive better training in econometric methods and procedures, and their familiarity with professional journals is deeper and more widespread. As a result a cynical senior who's goal is to earn a decent grade on their senior thesis while putting in the least possible time and effort is now better able to carry out some checklist; i.e., write a paper containing: (a) a multiple regression model, (b) specification tests: *x*, *y*, and *z*, (c) a residual analysis, and (d) a literature review containing five journal articles. But as we discover each year, papers satisfying such checklists can be utterly devoid of any intellectual quality. Thus the senior medians discussed in the previous paragraph could have been measured correctly, despite the surface differences.

### **(B) Is Motivation the Primary Obstacle?**

Let's now consider the last possibility, and in our opinion the most likely explanation of our struggle. Psychologists have proposed theories of expertise which purport to explain how people can become better at performing complex tasks. One of the most highly regarded of these theories of expertise is K.A. Ericsson's theory of *deliberate practice* (Ericsson, Krampe, & Tesch-Romer, (1993)). According to Ericsson, the acquisition of expertise requires the following four necessary conditions (ibid, p. 367) which combine to define deliberate practice:

**DP1** *Subjects must have “motivation to attend to the task and exert effort to improve their performance.”*

**DP2** *“The design of the task should take into account the preexisting knowledge of the ... [subjects] ... so that the task can be correctly understood after a brief period of instruction.”*

**DP3** *“The subjects should receive immediate informative feedback and knowledge of results of their performance.”*

**DP4** *“The subjects should repeatedly perform the same or similar tasks.”*

To what degree does our curriculum enable our majors to develop expertise in the complex skill of “thinking like an economist”? Have we succeeded in putting these four necessary conditions into practice? Let’s set aside condition **DP1** for now, and address conditions: **DP2**, **DP3**, and **DP4** first.

If you recall the *Theme 4* discussion in Section (II), we have set up a system to insure that conditions: **DP2** and **DP4** occur for all of our economics majors. We doubt, however, if condition **DP3** regularly occurs with the various coherent argument assignments (see Table 1) across our curriculum. Why? Most of these coherent argument assignments are due at the end of the semester, and it has been our experience that if they know their paper grade very few students are willing to pursue deeper feedback on their coherent arguments once the course is completed. For example, going back to our introduction, remember that one of us graded 107 coherent



arguments at the end of this past spring semester and posted the paper grades on-line; yet after seeing their grade, only two students expressed a desire to know more about the paper's evaluation. Of course this predictable student response saves us a lot of time when grading coherent arguments – we know there is no need to write down detailed comments on these end-of-semester papers – but it hurts our implementation of condition **DP3**.

Note that our situation with respect to condition **DP3** may not be as dire as it seems. While very few pursue end-of-semester paper feedback after the paper is graded, we have seen many more students pursue end-of-semester paper feedback before they turn in their final paper. For example, returning to those 107 coherent arguments just mentioned, we estimate that about a third of the students producing these papers took the initiative and asked the instructor to comment on preliminary drafts of their coherent arguments. So while there was no formal mechanism in these three classes to insure that condition **DP3** occurred, some students took action to make sure that condition **DP3** happened for them. What characteristic was shared by the students who, on their own, initiated “*immediate informative feedback and knowledge of results of their performance*”? We hypothesize that these students are the ones that have that extra bit of motivation to “... *attend to the task and exert effort to improve their performance.*” In other words, there is a weakness in our system. We probably do not do enough to guarantee that condition **DP3** is true of all majors when they complete their practice coherent arguments. In many cases only those majors who are strongly motivated, only those who already satisfy condition **DP1**, will in turn satisfy condition **DP3**.

With motivation pushed to the forefront, we can now see how a group of majors that lack enough motivation can prevent us from attaining universal competence even after we pushed back deadlines, created opportunities to practice on simpler coherent arguments, and began senior thesis instruction. If a senior lacks motivation then we may see a flurry of activity from that person right before the deadlines, but nothing much may happen in between deadlines. Thus for seniors who do not care (enough), pushing back deadlines may not increase the amount of time devoted to the senior thesis. If a senior lacks motivation then that person may not pursue immediate informative feedback on the simpler coherent arguments, hence may not acquire the necessary amount of deliberate practice. Finally, if a senior lacks motivation then that person may simply abuse (or waste) the senior thesis instruction.<sup>12</sup>

Therefore the following fixed-proportion production function **(9)** may be a better model of senior thesis production.<sup>13</sup>

$$\mathbf{(9)} \quad Q(t) = \text{Minimum}(\mathbf{Motivation}(t), X(t))$$

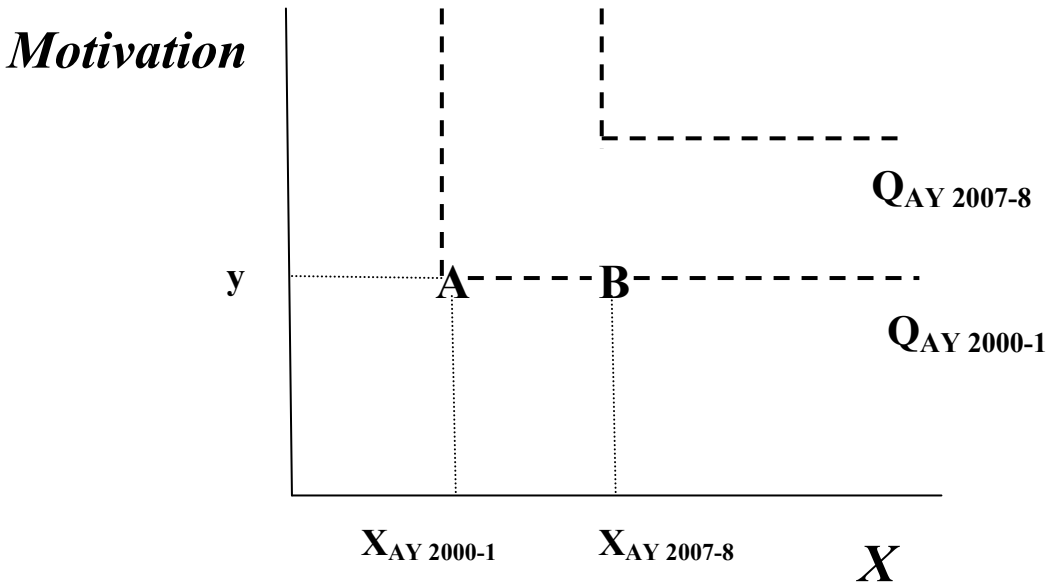
According to **(9)**, the level of motivation controls the link between  $X$  and  $Q$ , hence determines whether an increase in  $X$  increases  $Q$ . The idea is best expressed in a picture, see Figure 5.

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<sup>12</sup> Recall the example of the cynical senior who creates the misconceived checklist after receiving senior thesis instruction.

<sup>13</sup>  $Q(t)$  and  $X(t)$  have the same interpretation in **(9)** as they did in **(1)**.

Figure 5



So our theory, as summarized in Figure 5, states that since the overall motivation level of our seniors has not increased over the last eight years, all of the effort we have invested into increasing  $X$  has been wasted, at least in terms of attaining our objective of universal competence. While the nature of our data, competency ratings, cannot show it; those senior majors with high motivation have benefitted from the investment in  $X$ , they are producing better (than competent) coherent arguments. And those senior majors who have senior medians less than one, who do not disappear no matter what we have done, do so because they are motivation-poor.

What's our next step? We have a working hypothesis: *It's all about motivation*, and many questions. Here are a few. How do we test this hypothesis? Can we measure motivation? Can we increase motivation? If we can manipulate motivation, will the benefits exceed the costs?

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## Appendix 1

### SCORING GUIDE FOR COHERENT ARGUMENTS

The following scoring guide serves two purposes: (1) to help you reflect on your own work and improve it and (2) so you know what you will be evaluated on. The following items do NOT constitute an OUTLINE for you to follow. There are a number of effective ways to organize a paper. However you organize it, these areas should be addressed.

We will use this guide to grade your paper. We will assign a score to each of these components and add them up to get your total score. The areas we will look at are:

- **Initial claim**
- **Backing**
- **Theory**
- **Empirical Evaluation**
- **Revised Claim and Summary**
- **Overall Quality of Writing**

**INITIAL CLAIM:** *the introduction of the thesis, its relevance and a brief indication of how you are planning to proceed in answering the questions.*

<b>Poor</b>	<b>Competent</b>	<b>Excellent</b>
No clear thesis	Clear, well-focused thesis  Some basic idea of why the question is interesting and why it is topic appropriate for economic analysis.	Clear well-focused thesis  Convinces the reader of the economic importance of the issue  Clearly demonstrates the originality of the work and places it within the context of the economic literature

**BACKING:** *the recognition and understanding of previous, relevant work in the area.*

<b>Poor</b>	<b>Competent</b>	<b>Excellent</b>
<p><i>Little or no</i> reference to articles in professional journals.</p> <p>References are not used as an integral part of the argument, or inappropriate references are used.</p>	<p><i>Some</i> reference to articles in professional journals.</p> <p>References are used to strengthen and focus the argument.</p>	<p>Numerous references are made to articles in professional journals and/or other original sources.</p> <p>Effectively appeals to the literature at ALL stages of the argument</p>

**THEORY:** *the use of economic reasoning as the basis for the argument.*

<b>Poor</b>	<b>Competent</b>	<b>Excellent</b>
<p>States but does not clearly explain how the theory is used to analyze the issue at hand; the espoused theory is not central to the argument.</p> <p>Given the context of the argument, someone else's theory is <i>improperly</i> applied.</p>	<p>Given the context of the argument, someone else's theory is <i>correctly</i> applied.</p> <p>Economic reasoning is clearly and logically explained.</p> <p>Where possible, some use of mathematical symbolism or graphs to explain theory.</p>	<p>Consistently uses economic concepts and terms when explaining reasoning.</p> <p>Extensive and effective use of symbolism and graphs to illuminate theory where appropriate.</p> <p><i>Creates a useful</i> extension to someone else's theory, and <i>correctly</i> applies it, given the context of the argument or combines multiple (existing) theories in an original and enlightening way.</p> <p>Considers and addresses specific assumptions of the argument.</p>

**EMPIRICAL EVALUATION:** *“Empirical” simply refers to evidence that comes from experience or experiments. Data can be thought of as any bit of evidence (e.g., historical, textual, national statistics, experimental results, computer-generated simulations, etc...). These data (loosely defined) must be used to evaluate the argument in a convincing, appropriate way.*

<b>Poor</b>	<b>Competent</b>	<b>Excellent</b>
<p>Uses either no evidence or only anecdotal evidence to evaluate the thesis.</p> <p>Uses data only for descriptive purposes.</p>	<p>Uses data or other historical evidence to evaluate the thesis.</p> <p>Makes explicit use of numerical estimates (mean, median, standard deviation), graphical analysis (scatter plots, line graphs, and box plots), or computer simulations where appropriate.</p> <p>If the data is numerical, inferential statistics (hypothesis testing, confidence intervals, regressions, etc...) are used, but in a very simple or superficial way.</p> <p>Reference to historical evidence is used for evaluation, but it is simplistic.</p>	<p>If the data is numerical, the use of sophisticated inferential statistics or computer simulations to evaluate the thesis.</p> <p>Demonstrates serious reflection on the process by investigating multiple alternative tests or model specifications in order to determine the robustness of the results (an attempt is made to evaluate the evaluation).</p> <p>Extensive appeals to historical evidence are evident and are applied in a sophisticated and creative manner.</p>

**REVISED CLAIM and SUMMARY:** *the understanding of one's results and reflection on the implications thereof.*

<b>Poor</b>	<b>Competent</b>	<b>Excellent</b>
<p>A <i>vague</i> and/or <i>ambiguous</i> summary of the argument's conclusion.</p> <p>This conclusion has a <i>weak</i> connection to the argument's theory and data.</p>	<p>A <i>well-stated</i> summary of the argument's conclusion.</p> <p>This conclusion is <i>explicitly</i> and <i>strongly</i> connected to the argument's theory and data.</p> <p>Some reflection on the implications of the results and possible unexplored issues.</p>	<p>A well-stated summary of the argument's conclusion, strongly connected with the theory and data work.</p> <p>Provocative reflection upon the implications of the conclusion with interesting new questions to be explored.</p> <p>Clearly understands the relationship between the paper's conclusions and previous work.</p> <p>Places results into the broader context of the literature or policy-making process.</p>

**OVERALL QUALITY OF WRITING:** *the overall quality of the paper's organization, style, and grammar.*

<b>Poor</b>	<b>Competent</b>	<b>Excellent</b>
<p>Poorly organized; the argument is difficult to follow.</p> <p>Fails to maintain focus throughout the argument.</p> <p>Unacceptable grammar, spelling and punctuation.</p>	<p>Clear organization; the argument is easy to follow.</p> <p>Good job maintaining focus throughout.</p> <p>Acceptable grammar, spelling and punctuation.</p>	<p>Well-organized and easy to follow.</p> <p>"The whole is greater than the sum of its parts."</p>



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