A TIME-DENOMINATED COST-BASED THEORY OF ACADEMIC PERFORMANCE STANDARDS: THE EVIDENCE FROM AN EXPERIMENT IN THE USE OF MASTERY LEARNING PROCEDURES IN A PROGRAMMED INSTRUCTION FORMAT

Carl B. Montano, Lamar University
Andrew W. Bacdayan, Lamar University

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ABSTRACT

The accountability provision of the 2002 No Child Left Behind (NCLB) Act requires states to set the standards against which the performance of their public schools are evaluated. Implicit in this provision is the assumption of a link between performance standards and student learning. This paper formulates a model constructed at the level of the individual learner and the specific learning task and tests it using data generated under a quasi-experiment involving the use of mastery learning procedures in a programmed instruction format to learn elementary matrix algebra. The results show a definitive and consistent causal relationship between the two variables. The results seem to validate the assumption underlying the nation's premier education law. The results also suggest the model could be a potential tool for evaluating educational policy initiatives.

INRODUCTION

While the mantra of the school reform movement that crested in the 1980s was content standards, the mantra of the current cycle of the movement is performance standards.[1] Implicit in this mantra is the assumption that performance standards and student learning are tightly linked. In fact, that assumption is the foundation of the accountability provision of the 2002 No Child Left Behind (NCLB) Act. That provision requires each state to set the standards against which the performance of its public elementary and secondary schools are subsequently evaluated. Furthermore, schools meeting their standards are rewarded and schools failing over time are sanctioned.

Perhaps due to its intuitive appeal, even academicians have readily accepted the assumption's validity. Consequently, only a few studies at both the empirical and theoretical levels have so far been undertaken. In this regard, the only two empirical studies (Betts and Grogger, 2000; Figlio and Lucas, 2004)[2] have found a positive correlation between the two variables. However, we find the report problematic for a couple of reasons. First, the studies represent the all too common case of putting the cart before the horse. That is, both studies first find a significant statistical correlation between performance standards and student learning and then offer possible explanations for the finding.

While the problem just identified is not by itself a fatal flaw, the second one is. More specifically, the Betts and Grogger (2000) study uses the school as its unit of analysis. At this aggregated level, the interpretation of the results becomes fraught with uncertainty primarily because it is either impossible to control for all of the variables affecting student learning or to disentangle the separate effects of other variables that are collinear with high performance standards. One such variable is teacher quality which Rivkin, Hanushek and Kain (1998) have identified to be a major source of variations in student learning within schools.

Also, in these studies school performance standards are measured by the difference between the actual grades received by the students and their performance in a subsequent standardized test.[3] It is therefore an *expost* piece of information that is known only after the learning activity has taken place but unknown at the outset by students who must respond to it. As such, it is difficult to tell whether higher student achievement is a response to a higher performance standard or to something else.

Although the Figlio and Lucas (2004) paper attempts to minimize the aggregation problem by using the teacher or classroom in a given school as the unit of analysis, the fact still remains it is still not disaggregated well enough to reach the level of the individual learner and the specific learning task. The failure to reach down to this lowest possible analytical unit is a shortcoming because of the existence of individual learning differences (Farley, 1981; Schuell, 1981; Tobias, 1981) that could conceivably influence how different individuals respond to higher performance standards. Also, the failure to conduct the analysis at the level of the leaning task overlooks the fact that different tasks or courses even if in the same curriculum have different levels of difficulty. Again, this poses a problem because student response to higher standards may differ depending upon the difficulty or rigor of the subject matter.

Unlike the empirical studies which at least show some evidence of a significant statistical link between performance standards and student learning, the theoretical studies (Becker and Rosen, 1990; Betts, 1998; Costrell, 1994) have yielded mixed results. We believe the reason for this is the inappropriate conception of the student's role. Before we address this issue, we first specify this study's main objective.

OBJECTIVE

This paper examines the relationship between student learning and performance standards using a method that allows us to isolate the effect of changes in the latter variable on the former, all other things remaining the same. Unlike the previous empirical studies, the approximation of the *ceteris paribus* condition in this study makes it possible to definitively tie changes in performance standards to student learning.

To implement the foregoing objective, the remaining parts of this paper will first discuss three alternative roles of the learner. It next identifies the appropriate role that best provides a rationale for linking academic performance standards and student learning and then formalizes a theoretical model based on that role. The paper then visits an early 1970s experiment and shows that even as the study was designed for a different purpose, it unintentionally generated precisely the data needed to test the model. It next transforms the theoretical construct into an empirical model by incorporating a number of other factors deemed to enhance learning efficiency. To detect the presence of any distributional effect on learning output of variations in performance standards, the paper also tests the model using different student groupings based on ability, gender, learning style and school of origin. The paper is capped with the inevitable discussion of results and policy implications.

THREE VIEWS OF THE LEARNER

As a first step in the implementation of this study's objective, we examine three different frameworks within which to view the role of the individual learner. First, the student maybe viewed as a consumer of a product called learning, i.e., the student is a customer. This seems to be the prevalent view among school administrators who frequently profess the need to satisfy their stakeholders. The problem with this view is that it reduces the teacher evaluation process to a consumer satisfaction survey which is highly subject to the vagaries of consumer or student perception. This is because work represents disutility and therefore when a teacher demands high standards of performance requiring hard work, he or she usually becomes unfairly perceived as being a bad and an ineffective teacher. That the theoretical studies referenced earlier (Becker and Rosen, 1990; Betts, 1998; Costrell, 1994) assume the existence of a utility function for each learner indicates these studies view the learner as such. However, the fact that their results are mixed perhaps indicates they may have incorrectly conceptualized the student's appropriate role.

Another view which is actually the oldest of the three discussed here originated from Nobel Prize laureate, Theodore Schultz (1959, 1961). Under this view, education is a form of human capital and therefore the individual learner assumes the role of an investor. If this is the case, then an examination of the link between academic performance standards and student learning would have to be undertaken within the framework of human capital theory. We invite others to investigate the implications of this role for establishing the link between performance standards and academic achievement.

To us, the most promising role, first suggested by Garner (1973) and later quantified by Bacdayan (1994, 1995, 1997), is that which views the individual student as a producer of learning. As such the learner can be viewed as a firm that produces a commodity called learning by combining instructional time and study effort with the services of the school's fixed physical infrastructure and the learner's given cognitive entry and other fixed characteristics. We formulate the theory suggested by this view in the next section.

THE THEORETICAL MODEL: THE STUDENT AS PRODUCER OF LEARNING

Given that the individual is a producer of learning, it follows that the quantity of learning produced becomes strictly a function of the cost of production which, for the learning process, has been demonstrated to be measurable in terms of elapsed or clock time (Bacdayan, 1994).

Within this context, the setting of a performance standard or goal increases learning for two reasons. First, when a goal is set, the mind becomes more focused and more attentive. And unlike an unfocussed mind which wanders all over the place, a focused mind increases *engaged* learning time. As defined by educational researchers (Carroll, 1963; Bloom, 1968; 1981; Walberg, 1988), *engaged* learning time is the proportion of the learner's actual *elapsed* or *clock* time that is spent productively. A learner may actually use up one hour listening to a lecture or reading an assignment but if half that time is spent daydreaming or chatting with somebody, only half of the time is productively engaged. Thus, while the *elapsed* or clock time spent learning is one hour, the *engaged* time is only 30 minutes. Since setting a goal make the mind more focused and more attentive, a larger if not all of the elapsed time is used productively.

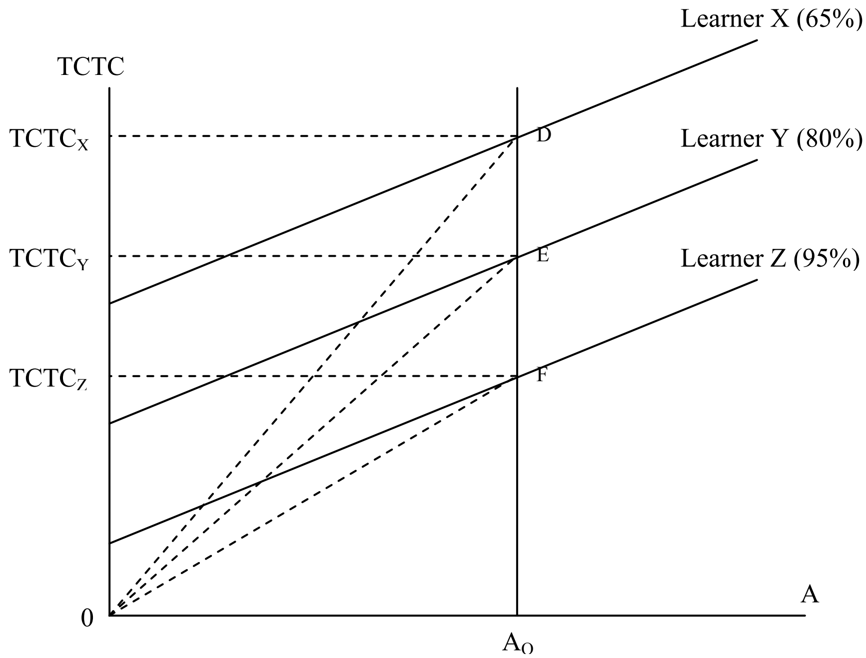
Secondly, when a goal is specified the tie-in between effort and reward becomes clearly defined and learners know exactly what they need to do to be able to attain the targeted performance level. Since we assume that learners crave for recognition not only from their peers but also from their teachers, parents and their community they are more likely to raise their expectations and work harder to attain the goal. Ignoring the fact that learners may also allocate more clock time to the activity, their heightened expectations will increase their motivation and the level of intensity with which they engage in the learning activity. Since a more intensely motivated learner is much more likely to process information more efficiently than one who is nominally committed, the specification of a performance goal ends up increasing student productivity and learning.

To summarize, the setting of a goal increases student learning for a given amount of *elapsed* or clock time because it not only increases the proportion of that time that is actually *engaged* in the learning process but it also raises the productivity of that engaged time. In effect, since goal setting makes the same amount of labor input more productive, the imposition of a performance standard becomes analogous to a technological improvement.

We formalize this proposition in Figure 1.[4] In the diagram, A is learning output or academic achievement measured by cumulative test scores and TCTC is the time-denominated cost measured by total clock time cost in minutes. The diagram also shows three time-denominated cost functions, one for Learner X who is assigned a 65% performance standard, another one for Learner Y who is assigned a performance standard of 80% and the last one is for Learner Z who is assigned the highest performance standard of 95%.

In Figure (1), Learner X is required to perform at a low performance standard or is allowed to use a low level technology and is therefore postulated to learn at the least efficient rate. Hence, he incurs a total clock time cost of $TCTC_X$ time units to produce A_0 units of learning output. For the same output level, A_0, Learner Y who is given a higher production technology to work with, i.e., he is assigned a higher performance standard, incurs a lower total clock time cost, $TCTC_Y<TCTC_X$. Learner Z is given the best technology, i.e., he is required to perform at the highest performance standard, and is therefore shown to be the most efficient of the three. That is, his elapsed or clock time cost for producing A_0 units of learning is $TCTC_Z<TCTC_Y<TCTC_X$.

FIGURE 1
THE EFFIFIENCY EFFECT OF ACADEMIC PERFORMANCE STANDARDS



Given the cost curves depicted in Figure 1, it follows that the efficiency at which the individual learns the task at a given achievement level is measured by the average total clock time total cost or ATCTC. For the given output level, A_0, Learner X's efficiency is measured by $ATCTC_X$, defined as the slope of the ray 0D or the ratio, ($TCTC_X/0A_0$). For Learner Y, efficiency is measured by the slope of the ray OE or $ATCTC_Y$= ($TCTC_Y/0P_0$) and for Learner Z, by the ratio, $ATCTC_Z=TCTC_Z/0A_0$) which is the slope of the ray, 0F. Since $ATCTC_Z< ATCTC_Y< ATCTC_X$ and since a lower ATCTC is associated with a higher efficiency and a higher ATCTC is associated with a lower efficiency, Figure (1) in effect suggests that for a given learning outcome such as A_0, there is an inverse relationship between ATCTC and the assigned performance standard (PSTND). Formally, all the foregoing suggests the following proposition:

$$ATCTC = f(PSTND), [d(ATCTC)/d(PSTND)] < 0 \qquad (1)$$

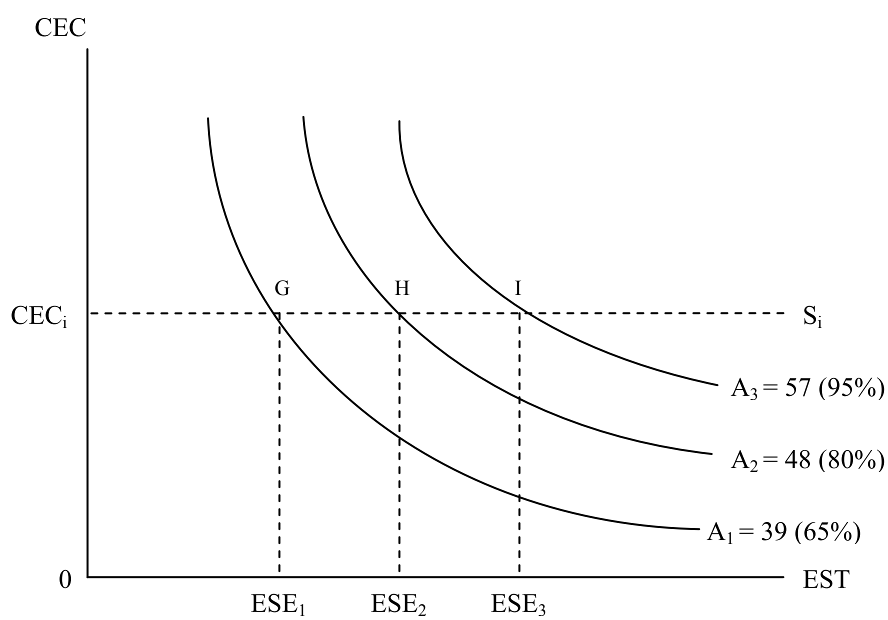
Note that this is a formalized version of the learning efficiency equation suggested by Bacdayan (1997).

THE DATA: VISITING GARNER'S 1973 EXPERIMENT

The basic source of the data used to test the model just proposed is a quasi-experiment conducted by Dr. William T. Garner for his Ph.D. dissertation at the University of Chicago in the early 1970s[5]. Involved in the experiment were 110 eighth graders from two different elementary schools in a racially homogenous suburban school district in the Midwest. The learning task was elementary matrix algebra and the method of instruction was mastery learning in a programmed instruction format.

As a study in mastery learning[6], Mr. Garner divided the whole task into three subtasks or lessons and each learner was randomly assigned one of three performance standards, namely, 65% mastery, 80% mastery and 95% mastery. The actual distribution of the performance standards ended up with 40 students being assigned the 65% level, 30 students the 80% level, and 37 students the 95% level. Each student was then instructed to study the first lesson and then take a test to determine if the mastery level assigned has been satisfied. If the test score satisfied the assigned performance goal, the learner moved on to the next lesson. If not, the learner was given two more chances to take alternative versions of the same test. Since there were three lessons for the whole task, each participant had at least 3 and at most 9 chances to attain the assigned goal or standard. All the pairings of study time and test scores were recorded sequentially for each participant. Also recorded were the randomly assigned performance standards, the cognitive entry characteristics (CEC), gender and school of origin for each participant. All these were preserved as an appendix to the author's dissertation study.

FIGURE 2
GARNER'S ISO-ACHIEVEMENT MAP

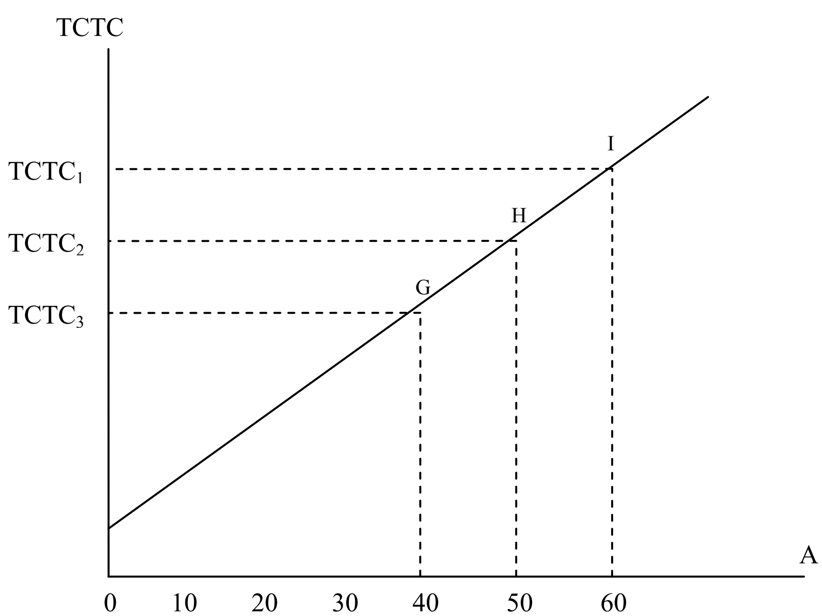


Called by the author a study in the allocation of time, the experiment's main objective was to determine the marginal rate of substitution between CEC and clock study time. To attain this objective, Dr. Garner attempted to identify three learning production iso-quants or iso-achievement curves, one each for the three performance levels. Since each one of the three lesson tests contained 20 questions, the total number of correctly answered questions for the whole task was 60. At 65% mastery, this means the predetermined learning output is a cumulative total score of 39. At 80% mastery, the goal is 48 correct answers and at 95%, the goal is 57.

Given the foregoing definition of the goals, the iso-achievement curve, A_1, in Figure 2 is therefore conceptually defined by the points generated by the pairs of CEC and *engaged* study effort (ESE) for each individual in the 65% subgroup. Likewise, A_2 was identified using all of the combinations of CEC and ESE generated by the subgroup assigned the 80% mastery performance standard. A_3 is described similarly.

Note that in attempting to identify the iso-achievement curves that make up the iso-achievement map in Figure 2, Dr. Garner unintentionally identified each individual's short run learning production function. To show why, assume student S_i has a cognitive entry characteristic of CEC_i. Since CEC_i is fixed for the duration of the experiment, its role is analogous to that of a fixed plant. In conventional microeconomics texts, the firm's short run production could then be derived from the information implicit in points G, H and I in Figure 2 and the cost curve in turn is derived from that short run production function.

FIGURE 3
THE CLOCK TIME-DENOMINATED LEARNING COST FUNCTION



Since engaged study effort is a fixed proportion of elapsed or clock time actually spent studying, we can directly derive each individual firm's learning cost function from Points G, H and I in Figure 2. This is done in Figure 3 which shows the time-denominated cost curve for an individual. In Figure 3, Point G' is defined by the total clock time cost ($TCTC_1$) associated with engaged study effort (ESE_1) and A_1 implied in Point G in Figure 2. Likewise, Points H' and I' are defined respectively by values of A and TCTC associated with ESE from Points H and I.

In reality, it is the clock time cost function depicted in Figure 3 that Dr. Garner actually identified[7] and it is that function which was estimated for all 110 participants by Bacdayan (1994)[8]. It is also on five different points on this same and every individual cost function that we calculated ATCTC.

THE EMPIRICAL LEARNING EFFICIENCY MODEL

To test the hypothesis as formalized in Equation (1), we need to specify the model more fully so we could control for possibly all of the non-PSTND variables affecting the individual learner's output for a given learning task. Fortunately, Dr. Garner also collected and recorded data on the additional variables which we think also enhance learning efficiency. Therefore, in addition to PSTND which has already been specified in Equation (1) and which will have a value of either 65%, 80% and 95%, the remaining independent variables will include the following:

MAPT is the student's score on a Matrix Arithmetic Pre-Test and is therefore a measure of specific prior knowledge. The coefficient of this variable is expected to be negative (-) because a higher pre-test score is an indication that the learner will spend less study time attaining the predetermined goal than another one with a lower MAPT. Thus the higher this score is, the more efficient the learner or the lower the ATCTC is. Hence, the postulated negative relationship.

SATAC is the participant's score on the Stanford Achievement Test on arithmetic concepts. Since this is a measure of general quantitative ability, a negative (-) sign is expected because the learner would be able to learn the subject easier, i.e., spend less time learning a given predetermined achievement level, the higher this ability.

SATPM is score on the Stanford Achievement Test on Paragraph Meaning which is a measure of verbal ability. The sign is expected to be negative (-) because a higher verbal ability means it is easier for the learner to follow instructions and would therefore spend less time learning a given predetermined achievement goal.

AVTT is the average testing time in minutes it takes the student to answer each question correctly and is assumed to measure learning style as described by Kagan, et al. (1964). It's coefficient is expected to bear a positive sign (+) because more cautious, less error-prone and therefore better performing students will spend more time answering each question while less cautious, more error-prone students and therefore low achieving students will spend less time. This is an important variable in the model because it controls for individual learning differences. This factor could introduce uncertainty in interpreting the results because different learners could respond to the same performance standard differently.

GDR is for the learner's sex. It is 0 if male and 1 if female. If males are more efficient in the learning of quantitative tasks, the sign of the coefficient accompanying this variable would be negative (-). If females are more efficient, then the sign would be positive (+).

SCHL denotes the school where the student comes from. In Garner's study, the participants came from two schools. One is preferred by less educated parents and the other one is preferred by more educated parents. Therefore, SCHL= 0 if the student comes from the former and SCHL=1 if the student comes from the latter. Since students coming from the more prestigious school are assumed to be more efficient learners, the expected sign for its coefficient would be negative (-). That is, for a given performance level, the lower value of 0 is associated with less efficiency or a higher ATCTC.

Since we believe there is a high degree of interaction among the variables, we use the multiplicative form of the learning function, which in log form assumes the following:

$$LnATCTC = a_0 + a_1(LnPSTND) + a_2(LnMAPT) + a_3(LnSATAC + a_4(LnSATPM) + a_5(LnAVTT) + a_6(LnGDR) + a_7(LnSCHL) + e \quad (2)$$

where the coefficients are all in percentages and e is the error term. Based on the predictions indicated in the discussion of each explanatory variable, we expect that $a_1<0$, $a_2<0$, $a_3<0$, $a_4<0$, $a_5>0$, $a_6<0$ or >0 and $a_7<0$. Table 1 presents a summary description of the data.

TABLE 1
SUMMARY STATISTICS: EXPLANATORY VARIABLES

	Mean	S.D.	N	Median	Min	Max
PSTND	79.59	12.60	110	80	65	95
MAPT	1.29	1.19	110	1	0	5
SATAC	18.64	6.27	110	19	4	34
SATPAM	32.33	10.17	110	33	0	52
AVTT	1.33	0.53	110	1.24	.42	3.14

GNDR	Dummy	0 for Female, 45 cases 1 for Male, 65 cases
SCHL	Dummy	0 for the less prestigious school, 62 cases 1 for the more prestigious school, 48 cases

Note that after PSTND, the next three explanatory variables (MAPT, SATAC, SATPM) are all learner cognitive entry characteristics (CEC), and the last three (AVTT, GDR and SCH) are non-cognitive student traits. AVTT controls for individual learning differences, GDR controls for the learner's sex and SCH controls for the differences between the two schools from which the participants were drawn. The fact that we are able to control for most if not all of the other variables affecting learning output make the study truly different from the more aggregated studies of Betts and Grogger (2000) and Figlio and Lucas (2004). More specifically, whereas these studies have not satisfied the *ceteris paribus* assumption, this study does or at least attempts to.

To determine if some of the independent variables in the model exert the same effect at different points on the learning curve, we calculated ATCTC at five different academic achievement levels, i.e., at A=21, A=30, A=39, A=48 and A=57. Consequently, we estimated five (5) equations, the respective dependent variables of which are $LnATCTC_{21}$, $LnATCTC_{30}$, $LnATCTC_{39}$, $LnATCTC_{48}$ and $LnATCTC_{57}$.

Finally, note that only those assigned a performance standard of 95% mastery were able to identify the whole breadth of their learning cost curves. Although those assigned lower performance standards were not able to do so, the equations describing their truncated learning curves were projected to make it possible to calculate the ATCTC at all five points throughout the whole curve for all of the participants.

THE RESULTS

One of the problems making the interpretation of OLS estimates difficult or uncertain is a high degree of collinearity among the explanatory variables. In this regard, Table 2 shows that for the whole group of independent variables, the only two with a high degree of correlation are AVTT and SATAC (-0.5284). Given this high correlation, it is possible that the coefficients associated with each one may not be statistically significant although both contribute significantly to the R^2 value. If the estimated coefficients of both variables come out being statistically significant in spite of this, then the problem becomes irrelevant.

TABLE 2
SIMPLE CORRELATION COEFFICIENTS

	PSTND	**MAPT**	**SATAC**	**SATPAM**	**AVTT**	**SEX**	**SCHOOL**
PSTND	1.0000						
MAPT	.0849	1.0000					
SATAC	.1548	**.3884**	1.0000				
SATPAM	-.0570	.1062	**.2973**	1.0000			
AVTT	-.1469	**-.3655**	**-.5284**	-.1677	1.0000		
SEX	-.0439	.0172	-.1573	.1356	-.1859	1.000	
SCHOOL	-.1232	-.1136	-.2059	-.0953	.0633	.0881	1.0000

With this confidence builder in place, we turn to Table 3 which presents the estimates of Equation 2 for the whole group. In this regard, a look at the F ratios indicate all of the equations estimated are highly acceptable and all have high explanatory powers as judged by their adjusted R^2 values, almost of all which are in the .80s. Clearly, all these indicate a robust model.

The main hypothesis tested is the postulated inverse relationship between learning efficiency as measured by ATCTC and academic performance standard denoted by PSTND. A glance at the table immediately reveals a strong and consistent support for this expectation. Not only is the coefficient of PSTND accompanied by a negative sign as expected, it is also statistically significant at better than the 1% level regardless of the performance level. This should dispel the notion that the effect of performance standards may be subject to diminishing returns.

TABLE 3
THE LEARNING EFFICIENCY EQUATIONS
FOR THE WHOLE GROUP

Explanatory Variables	**Dependent Variable** $LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constan	**3.1504**	**3.5994**	**3.9296**	**4.1910**	**4.4073**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	**-0.3980**	**-0.4810**	**-0.5421**	**-0.5904**	**-0.6304**
	(p=.02)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnMAPT	**-0.1228**	**-0.0760**	-0.0443	-0.0180	-0.0038
	(p=.02)	*(p=.06)*	*(p=.28)*	*p=.69)*	*(p=.90)*
LnSATAC	**-0.4568**	**-0.4296**	**-0.4096**	**-0.3938**	**-0.3807**
	p=.00)	*(p=.00)*	*(p=00.)*	*(p=.00)*	*(p=.00)*
LnSATPM	-0.0046	-0.0098	-0.0139	-0.0172	-0.0194
	(p=.89)	*(p=.79)*	*(p=.72)*	*(p=.69)*	*(p=.68)*
LnAVTT	**0.8053**	**0.8254**	**0.8402**	**-0.8518**	**-0.8615**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=. 00)*
LnSEX	0.0322	0.0294	0.0274	0.0257	-0.0244
	(p=.69)	*(p=.65)*	*(p=.67)*	*(p=.72)*	*(p=.75)*
LnSCHL	-0.0693	**-0.1069**	**-0.1346**	**-0.1565**	**-0.1746**
	(p=.37)	*(p=.08)*	*(p=.03)*	*(p=.02)*	*(p=.02)*
N	110	110	110	110	110
DF	102	102	102	102	102
F RATIO	51.03	77.02	77.40	62.78	48.68
Adj. R^2	0.764	.830	0.830	0.831	0.799

On the contrary, the results show that the effect of variations in the mastery performance standard becomes stronger at higher performance levels. This is evident from the fact that the absolute size of the coefficient has grown from -0.3980 for the lowest performance level of 35% (21 correct answers out of 60) to -0.6304 for the highest mastery performance level of 95% mastery or 57 correct answers.

In addition to a test of the main hypothesis, the results reveal a number of important findings and observations. First, the sign accompanying the coefficient of MAPT fulfills the expectation. However, it is significant only when ATCTC is measured at the low achievement levels of P=21 and P=30. Since MAPT is a matrix arithmetic pretest score and is therefore a measure of specific knowledge on the subject, we think it merely confirms the common observation that specific knowledge about a subject may be helpful initially but it does not have a lasting effect. This is perhaps best illustrated by repeaters in a course who usually do well at the first few tests but lose their advantage as the course progresses.

Secondly, it reveals that the strongest and most consistent cognitive entry characteristic affecting learning efficiency is general quantitative ability as measured by SATAC, the student's score on the Stanford Achievement Test on Arithmetic Concepts. At all mastery performance levels, its coefficient has consistently bore the expected negative sign. In addition, its coefficient has exhibited a consistently high statistical significance level which is at better than the 1% level. Again this result simply reinforces the well-known observation that general quantitative ability is probably the most important cognitive entry characteristic needed for learning mathematical tasks.

Thirdly, although the coefficient of verbal ability as measured by SATPM has an acceptable sign, it does not seem to matter at all, i.e., the significance level is not acceptable at any performance standard level. This would seem to be consistent with the observation that people who have high literary ability do not always fare well in quantitatively-oriented learning tasks.

Fourth, GDR does not seem to influence learning efficiency regardless of the performance level. While this seems to contradict the conventional wisdom that males do better in math subjects than females, it may well be the effect of the teaching method used. One of the strengths of mastery learning as a learning system is the fact that it is designed in such a way that expectations are equalized. In other words, when learning objectives are clearly defined, the conditions under which it is deemed to have been mastered are specified and all learners are given every opportunity to master it, expectations are all raised and equalized for all students, male and female.

Fifth, consistent with the expectation earlier indicated, the coefficient of AVTT which was noted earlier to be a possible measure of learning style is significant at better than the 1% level. This indicates it is in fact a very important determinant of learning efficiency although in an obverse way since the coefficient has a positive sign.

Sixth, school seems to matter after all. Although the significance level apparently becomes acceptable only at higher achievement levels, its coefficient bears a negative sign. Since the more prestigious school was assigned a value of 1 and the other one deemed less so was coded 0, this result suggests that students from the more prestigious school are more efficient than those from the less prestigious school.

MORE RESULTS: THE DISTRIBUTIONAL EFFECTS

To determine if the pooling of the data for the whole group does not submerge any distributional effect of performance standards, we estimated the learning efficiency equations for different groups based on general ability as measured by SATAC, gender (GNDR), school (SCHL) and learning styles (AVTT). In separating the groups by SATAC and AVTT, the cutoff point is the median value.[9]

Unlike the previous empirical studies which showed that higher ability students respond to higher performance standards better than lower ability students, our results present a different picture. Thus, Table (4) clearly shows that performance standard is a highly significant factor in both the high SATAC and low SATAC groups. If anything, Table (4) shows that the magnitudes of the coefficients are larger for the lower ability group. However, the fact that the coefficient of LnPSTND where the dependent variable is $LnATCTC_{57}$ seems to indicate that PSTND becomes irrelevant at higher performance levels for the higher ability students.

TABLE 4
THE LEARNING EFFICIENCY EQUATIONS BY ABILITY
A. LOWER ABILITY STUDENTS, 59 CASES

Explanatory	Dependent Variable				
Variables	$LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**2.4085**	**3.5461**	**4.3830**	**5.0453**	**5.5935**
	(p=.02)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	**-0.4264**	**-0.6112**	**-0.7470**	**-0.8546**	**-0.9436**
	(p=.05)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnMAPT	**-0.0285**	**-0.1319**	-0.0755	-0.0309	-0.0060
	(p=.03)	*(p=.01)*	*(p=.16)*	*(p=.61)*	*(p=.93)*
LnSATPM	-0.0867	-0.1407	**-0.1804**	**-0.2119**	**-0.2380**
	(p=.52)	*(p=.18)*	*(p=.09)*	*(p=.08)*	*(p=.09)*
LnAVTT	**0.7453**	**0.7192**	**0.7000**	**-0.6844**	**-0.6722**
	(p=00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnSEX	0.1586	0.1121	0.0778	0.0507	0.0283
	p=.13)	*(p=.18)*	*(p=.35)*	*(p=.59)*	*(p=.80)*
LnSCHL	-0.0282	-0.0749	-0.1084	-0.1353	-0.1576
	(p=.38)	*(p=.34)*	*(p=.18)*	*(p=.14)*	*(p=.13)*
N	59	59	59	59	59
DF	52	52	52	52	52
F RATIO	14.84	22.86	22.57	18.00	14.09
Adj. R^2	0.589	.693	0.691	0.938	0.575

B. HIGHER ABILITY STUDENTS, 51 CASES

Explanatory	Dependent Variable				
Variables	$LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**2.5360**	**2.3274**	**2.1739**	**2.0525**	**1.9519**
	(p=.04)	*(p=.02)*	*(p=.03)*	*(p=.06)*	*(p=.08)*
LnPSTND	**-0.5642**	**-0.4822**	**-0.4219**	**-0.3742**	-0.3347
	(p=.03)	*(p=.03)*	*(p=.05)*	*(p=.09)*	*(p=.16)*
LnMAPT	-0.0897	-0.0787	-0.0706	-0.0642	-0.0589
	(p=.29)	*(p=.26)*	*(p=.29)*	*(p=.36)*	*(p=.44)*
LnSATPAM	-0.0337	-0.0321	-0.0309	-0.0300	-0.0292
	(p=.55)	*(p=.49)*	*(p=49.)*	*(p=.53)*	*(p=.57)*
LnAVTT	**-0.8177**	**-0.8650**	**-0.8998**	**-0.9273**	**-0.9501**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnSEX	-0.0893	-0.0178	0.0347	-0.0763	-0.1107
	(p=.48)	*(p=.56)*	*(p=.73)*	*(p=.47)*	*(p=. 34)*
LnSCHL	-0.2374	-0.2280	-0.2216	-0.2155	-0.2109
	(p=.07)	*(p=.04)*	*(p=.04)*	*(p=.05)*	*(p=.08)*
N	51	51	51	51	51
DF	44	44	44	44	44
F RATIO	13.05	19.64	21.81	20.19	17.45
Adj. R^2	0.591	.691	0.714	0.697	0.704

The same general tendency is exhibited by the different groups based on GDR and SCHL. In both groupings, the performance standard (PSTND) is a consistently significant determinant of learning efficiency regardless of the student's sex or school of origin.

TABLE 5
THE LEARNING EFFICIENCY EQUATIONS BY GENDER

A. MALES, 65 CASES

Explanatory Variables	Dependent Variable $LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**2.4578**	**3.2720**	**3.8710**	**4.3450**	**4.7373**
	(p=.01)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	**-0.2584**	**-0.3977**	**-0.5002**	**-0.5813**	**-0.6484**
	(p=.02)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnMAPT	**-0.1446**	**-0.0919**	-0.0531	-0.0245	-0.0029
	(p=.03)	*(p=.09)*	*(p=.32)*	*(p=.71)*	*(p=.97)*
LnSATAC	**-0.4409**	**-0.4460**	**-0.4498**	**-0.4528**	**-0.4553**
	(p=.00)	*(p=.00)*	*(p=00.)*	*(p=.00)*	*(p=.00)*
LnSATPM	-0.0122	-0.0021	-0.0953	-0.0117	-0.0160
	(p=.81)	*(p=.96)*	*(p=.89)*	*(p=.80)*	*(p=.75)*
LnAVTT	**0.7666**	**0.7874**	**0.8027**	**-0.8148**	**-0.8249**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=. 00)*
LnSCHL	-0.0476	**-0.1398**	**-0.2076**	**-0.2613**	**-0.3057**
	(p=.63)	*(p=.08)*	*(p=.01)*	*(p=.00)*	*(p=.00)*
N	65	65	65	65	65
DF	58	58	58	58	58
F RATIO	36.71	57.85	59.00	48.58	38.53
Adj. R^2	0.770	.842	0.845	0.817	0.779

B. FEMALES, 45 CASES

Explanatory Variables	Dependent Variable $LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**4.9672**	**4.7425**	**4.5772**	**4.4464**	**4.3381**
	(p=.01)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	**-0.7051**	**-0.6545**	**-0.6172**	**-0.5878**	**-0.5634**
	(p=.02)	*(p=.01)*	*(p=.01)*	*(p=.02)*	*(p=.04)*
LnMAPT	-0.0705	-0.0372	-0.0122	-0.0070	-0.0241
	(p=.43)	*(p=.60)*	*(p=.86)*	*(p=.92)*	*(p=.77)*
LnSATAC	**-0.3926**	**-0.3585**	**-0.3335**	**-0.3136**	**-0.2972**
	(p=.02)	*(p=.01)*	*(p=02.)*	*(p=.03)*	*(p=.06)*
LnSATPM	-0.1941	-0.1837	-0.1760	-0.1700	-0.1650
	(p=.44)	*(p=.36)*	*(p=.37)*	*(p=.42)*	*(p=.48)*
LnAVTT	**0.9210**	**0.8826**	**0.8544**	**-0.8321**	**-0.8136**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=. 00)*
LnSCHL	-0.1280	-0.0794	-0.0436	-0.0153	-0.0081
	(p=.33)	*(p=.45)*	*(p=.67)*	*(p=.81)*	*(p=.95)*
N	45	45	45	45	45
DF	38	38	38	38	38
F RATIO	22.87	30.64	29.67	23.66	17.18
Adj. R^2	0.749	.802	0.796	0.756	0.697

TABLE 6
THE LEARNING EFFICIENCY EQUATIONS BY SCHOOL

A. SCHOOL ATTRACTING CHILDREN WITH LESS EDUCATED PARENTS, 62 CASES

Explanatory Variables	**Dependent Variable** $LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**3.8269**	**4.0329**	**4.1815**	**4.3044**	**4.4037**
	(p=.01)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	**-0.4687**	**-0.5096**	**-0.5397**	**-0.5635**	**-0.5832**
	(p=.04)	*(p=.01)*	*(p=.00)*	*(p=.01)*	*(p=.01)*
LnMAPT	-0.0775	-0.0331	-0.0004	-0.0254	-0.0468
	(p=.28)	*(p=.56)*	*(p=.99)*	*(p=.68)*	*(p=.49)*
LnSATAC	**-0.5086**	**-0.4733**	**-0.4474**	**-0.4268**	**-0.4098**
	(p=.00)	*(p=.00)*	*(p=00.)*	*(p=.00)*	*(p=.00)*
LnSATPM	-0.0616	-0.0576	-0.0546	-0.0523	-0.0503
	(p=.38)	*(p=.31)*	*(p=.33)*	*(p=.39)*	*(p=.46)*
LnAVTT	**0.6227**	**0.6934**	**0.7454**	**-0.7867**	**-0.8207**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=. 00)*
LnSEX	-0.0310	-0.0624	-0.0854	-0.1037	-0.1188
	(p=.80)	*(p=.53)*	*(p=.38)*	*(p=.33)*	*(p=.32)*
N	62	62	62	62	62
DF	55	55	55	55	55
F RATIO	23.44	37.47	40.18	34.48	27.95
Adj. R^2	0.719	.808	0.794	0.767	0.726

B. SCHOOL ATTRACTING CHILDREN WITH MORE EDUCATED PARENTS, 48 CASES

Explanatory Variables	**Dependent Variable** $LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**2.6957**	**3.3077**	**3.7580**	**4.1143**	**4.4092**
	(p=.02)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	-0.3644	**-0.4764**	**-0.5588**	**-0.6241**	**-0.6780**
	(p=.14)	*(p=.02)*	*(p=.01)*	*(p=.01)*	*(p=.01)*
LnMAPT	**-0.2027**	**-0.1472**	**-0.1064**	-0.0741	-0.0473
	(p=.01)	*(p=.02)*	*(p=.09)*	*(p=.29)*	*(p=.55)*
LnSATAC	**-0.4009**	**-0.3959**	**-0.3922**	**-0.3893**	**-0.3869**
	(p=.01)	*(p=.00)*	*(p=00.)*	*(p=.00)*	*(p=.01)*
LnSATPM	-0.0363	-0.0267	-0.0197	-0.0142	-0.0096
	(p=.61)	*(p=.64)*	*(p=.73)*	*(p=.83)*	*(p=.90)*
LnAVTT	**0.9182**	**0.8875**	**0.8650**	**-0.8471**	**-0.8324**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=. 00)*
LnSEX	-0.0095	-0.0606	-0.0983	-0.1281	-0.1527
	(p=.93)	*(p=.49)*	*(p=.27)*	*(p=.20)*	*(p=.18)*
N	48	48	48	48	48
DF	41	41	41	41	41
F RATIO	40.16	57.15	52.77	39.75	29.28
Adj. R^2	0.833	.878	0.869	0.832	0.783

Unlike the others, the grouping by learning style as measured by AVTT indicates that while performance standards is not a significant determinant of learning efficiency among students whose learning styles are described as impulsive responders, it continues to be a significant variable among those who are described as reflective responders. This does not seem to be revelatory of something new about the learning process. It just seems to be consistent with the definition of an impulsive responder. That is, if an impulsive responder is one who responds impulsively, then his test score would have no bearing on whether or not he was assigned a low or a high performance standard requirement.

TABLE 7
THE LEARNING EFFICIENCY EQUATIONS BY LEARNING STYLE

A. IMPULSIVE RESPONDERS, 55 CASES

Explanatory Variables	Dependent Variable $LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**5.4175**	**5.0075**	**4.7059**	**4.4672**	**4.2692**
	(p=.02)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	**-0.5198**	-0.4406	-0.3823	-0.3362	-0.2980
	(p=.07)	*(p=.10)*	*(p=.16)*	*(p=.24)*	*(p=.33)*
LnMAPT	**-0.2810**	**-0.2592**	**-0.2431**	**-0.2304**	**-0.2199**
	(p=.00)	*(p=.00)*	*(p=.01)*	*(p=.01)*	*(p=.03)*
LnSATAC	**-1.0011**	**-0.9411**	**-0.8971**	**-0.8622**	**-0.8333**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnSATPAM	0.0302	0.0344	0.0374	-0.0399	-0.0419
	(p=.64)	*(p=.57)*	*(p=.54)*	*(p=.54)*	*(p=.54)*
LnSEX	0.1582	0.1085	0.0719	0.0430	0.0190
	(p=.25)	*(p=.40)*	*(p=.58)*	*(p=.75)*	*(p=.89)*
LnSCHOOL	**-0.3731**	**-0.3622**	**-0.3541**	**-0.3478**	**-0.3425**
	(p=.01)	*(p=.01)*	*(p=.01)*	*(p=.01)*	*(p=.02)*
N	55	55	55	55	55
DF	48	48	48	48	48
F RATIO	10.52	10.63	9.35	7.83	6.50
Adj. R^2	0.514	.517	0.481	0.431	0.379

B. REFLECTIVE RESPONDERSS, 55 CASES

Explanatory Variables	Dependent Variable $LnATCTC_{21}$	$LnATCTC_{30}$	$LnATCTC_{39}$	$LnATCTC_{48}$	$LnATCTC_{57}$
Constant	**4.5258**	**5.6093**	**6.4063**	**7.0371**	**7.5591**
	(p=.00)	*(p=.00)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnPSTND	-0.4581	**-0.6366**	**-0.7679**	**-0.8719**	**-0.9579**
	(p=.11)	*(p=.01)*	*(p=.00)*	*(p=.00)*	*(p=.00)*
LnMAPT	-0.0721	-0.0028	-0.0579	-0.1014	-0.1375
	(p=.44)	*(p=.97)*	*(p=.42)*	*(p=.20)*	*(p=.12)*
LnSATAC	**-0.3479**	**-0.3612**	**-0.3710**	**-0.3787**	**-0.3851**
	(p=.03)	*(p=.01)*	*(p=.00)*	*(p=.01)*	*(p=.01)*
LnSATPAM	**-0.3371**	**-0.3702**	**-0.3945**	**-0.4138**	**-0.4298**
	(p=.06)	*(p=.01)*	*(p=.01)*	*(p=.01)*	*(p=.01)*
LnSEX	0.1196	0.00286	0.0554	0.0339	0.0160
	(p=.40)	*(p=.47)*	*(p=.62)*	*(p=.78)*	*(p=.90)*
LnSCHL	0.0982	0.0188	-0.0397	-0.0859	-0.1241
	(p=.43)	*(p=.85)*	*(p=.68)*	*(p=.41)*	*(p=.29)*
N	55	55	55	55	55
DF	48	48	48	48	48
F RATIO	6.04	9.12	10.20	9.36	8.12
Adj. R^2	0.359	.474	0.505	0.482	0.442

CONCLUDING OBSERVATIONS AND POLICY IMPLICATIONS

Based on the foregoing results, allow us to make two observations. First, we believe the model formulated and tested here is a good one. As such, it is a potential tool for evaluating other education reform initiatives. Secondly, the results show that the assumed positive link between academic performance and student learning outcome is much more definitive than what the findings of the previous studies would seem to indicate. We are emboldened to make the second observation because of the following:

First, the use of a programmed instruction format eliminated the use of teachers. The use of different teachers to teach different students included in a sample presents difficulties because higher quality teachers usually have higher academic performance standards and therefore it becomes difficult to separate the effects of the two. In effect, the use of a programmed instruction format eliminated the uncertainty arising from the collinearity between teacher quality and performance standards.

Second, the three mastery performance standards have been assigned randomly. This is important because it eliminates the bias resulting from the possibility that the high standard may be preponderantly associated only with high ability students, or only to males or females, or only to students coming from more prestigious schools. All these could happen when non-experimental field data is used.

Third, the use of the mastery learning system ensures that the learner does not move on to the next level in the learning task hierarchy without satisfying the assigned performance standard on the preceding task. This constant awareness of the existence of a standard makes it difficult for the learner to ignore it. The effect of this is to ensure that the learner reacts to the assigned standard.

Finally, all of these reasons are doubly enhanced by the fact that unlike all of the previous studies cited, this study is conducted at the lowest possible unit of analysis. This should eliminate most if not all other problems that make it difficult to attribute the effect of variations in the academic performance standard to variations in learning outcomes.

If most or all of the conceivable sources of uncertainty in interpreting the effect of variations in performance standards on student learning outcomes have in fact been controlled for as we think they have been in our study, then the evidence supporting the assumed positive link between the two is definitive. It also follows that the accountability provision of the 2002 NCLB Act seems to rest on solid ground.

ENDNOTES

1. Academic standards could be content-based or performance-based. The first one refers to what must be covered in a course or program while the second one refers to how well the content is learned. The focus of this study is on performance standards.
2. The third empirical study ever undertaken was reported by Lillar and DeCicca (2004). However, this study examined the effect of course graduation requirements which falls under content standards. For whatever it is worth, the two authors found that the effect of higher graduation standards is a higher drop out rate.
3. In Figlio and Lucas (2004), the formula that quantifies this standard is given by

$$\text{Standards}_t = \sum_i \sum_y (\text{FCAT}_{ity} - \text{grade}_{ity})/n$$

   In the formula, FCAT is Florida Comprehensive Assessment Test, t represents the teacher, i represents the student, y represents the year and n reflects the number of student-year pairs faced by the teacher. The higher the value of Standards, the higher the standard because it suggests that students require a higher score on the FCAT to achieve a given letter grade.

4. In standard microeconomics textbooks, the curves would increase first at a decreasing rate before continuing to increase at an increasing rate. Also, the vertical axis would be labeled TC, and the horizontal axis, Q. For simplicity, we assume the time-denominated cost functions to be linear.
5. We graciously acknowledge Dr. Garner's permission to use his data. Although the letter was to permit use of his data in the preparation of a study published in 1994, we are taking the liberty of using the same permission to apply to this study which uses results from the 1994 publication. Also, note that as the data was collected more than 30 years ago and for a different purpose at that, we used it because it is made to order for this study. Also, we would have been unable to muster the resources required to duplicate the experiment, given that schools are now subject to more stringent policies and regulations especially on the use of human subjects. A final reason is our belief that there is no difference between the responses of eighth graders in the early 1970s and eighth graders in the early 2000s to academic performance requirements.
6. For more information on the theory and implementation of mastery learning, see Bloom (1968), Block & Anderson (1975) and Guskey (1985).
7. The title of Dr. Garner's dissertation, *The Identification of an Educational Production Function by Experimental Means*, suggests he was identifying the iso-achievement curves in Figure 2. That is not possible because engaged study effort (ESE) can not be observed.
8. The regression method used is the Least Squares Dummy Variable Model developed by W. H. Greene (1993, pp. 465-469). This model makes it possible to estimate the individual intercepts using only one regression equation. Of the various functional forms estimated, the best fit to the data was accomplished with the use of the semi-log form. Therefore, the equations estimated for each one of the 110 participants was LnT=a+bP. For simplicity, we assumed the time cost functions to be linear.
9. Table 4 shows that instead of 55 cases for each as the median score cut off would suggest, the lower ability group contains 59 cases and the higher ability group, 51 cases instead of 55 for each one. This is due to the fact that the median value of 19 is observed for several learners which occupy the middle of the table of array. As a result we just included all with a SATAC score of 19 in the lower ability group.

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