

## **ARE NATIONAL EXIT EXAMINATIONS IMPORTANT FOR EDUCATIONAL EFFICIENCY?**

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In many countries national or provincial exit examinations certify and signal the achievements of secondary school students to universities and employers. These examinations are thought to have significant effects on how teachers teach and how students study, so the character of these examinations has been a source of controversy in many countries. Efforts to reform secondary education almost always involve changes in the examination systems. The English merged the old Certificate of Secondary Education (CSE) and the O level exams into the General Certificate of Secondary Education (GCSE). France has broadened the list of Baccalaureate Examinations to include numerous vocational specialties and has set a goal of over 80 percent of the age cohort participating by the year 2000. The Brevet exam at the end of lower secondary school, which had been abolished in 1977, was re-introduced in 1986. "The reasons were that the results had been declining in the experience of many people....(Kreeft 1990 p. 6)." The Canadian provinces of Manitoba and New Brunswick are reestablishing curriculum-based exit examinations that had been discontinued in the early 1970s.

Curriculum-based external exit exams (CBEEEs) are also being considered in the United States. The Competitiveness Policy Council, for example, advocates that "*external assessments be given to individual students at the secondary level and that the results should be a major but not exclusive factor qualifying for college and better jobs at better wages* (1993, p. 30)." The American Federation of Teachers advocates a system in which:

Students are periodically tested on whether they're reaching the standards, and if they are not, the system responds with appropriate assistance and intervention. Until they meet the standards, they won't be able to graduate from high school or enter college (AFT 1995 p. 1-2).

These two quotes are representative of the views of a substantial number of educational reformers in the countries that do not currently have a system of diploma examinations. These reformers argue that 'curriculum-based external exit exam systems', CBEEES, based on world class content standards will improve teaching and learning of core subjects. Is this claim justified? This paper analyzes data from four large scale international studies of student achievement and attempts to answer this question.

## I. THEORY—WHY CURRICULUM-BASED EXTERNAL EXIT EXAMS CHANGE INCENTIVES?

### 1.1 What is a Curriculum-Based External Exit Examination System?

Critics of moves to establish or reestablish exit examination systems point out that students already take lots of teacher made tests. American student also take lots of nationally standardized tests. They ask "Why should a curriculum-based external exit examination system significantly improve incentives and learning?" The response of CBEEES advocates is that they have uniquely powerful incentive effects because they have the following six characteristics. They:

1. **Produce signals of student accomplishment that have real consequences for the student.**

2. **Define achievement relative to an external standard, not relative to other students in the classroom or the school.** Fair comparisons of achievement across schools and across students at different schools are now possible. Costrell's (1994a, b) formal analysis of the optimal setting of educational standards concluded that more centralized standard setting (state or national achievement exams) results in higher standards, higher achievement and higher social welfare than decentralized standard setting (ie. teacher grading or schools graduation requirements).
3. **Are organized by discipline and keyed to the content of specific course sequences.** This focuses responsibility for preparing the student for particular exams on a small group of teachers.
4. **Signal multiple levels of achievement in the subject.** If only a pass-fail signal is generated by an exam, the standard will have to be set low enough to allow almost everyone to pass and this will not stimulate the great bulk of students to greater effort (Kang 1985; Costrell 1994a). By age 13 students differ dramatically in their levels of achievement. On the National Assessment of Educational Progress, 7-9 percent of 13 year olds are four or more grade level equivalents behind their age mates and 15-17 percent are four or more grade level equivalents ahead. When achievement differentials among students are as large as this, incentives for effort are stronger for most students if the full range of achievement is signaled rather than just whether the individual has passed some absolute standard. When only a pass-fail signal is generated by a test, many students pass without exertion and are, thus, not stimulated to greater effort by the reward for passing. Some of the least well prepared students will judge the effort required to achieve the standard to be too great and the benefits too small to warrant the effort. They give up on the idea of meeting the standard. Few students will find the reward for exceeding a single absolute cutoff an incentive for greater effort (Kang 1985). Costrell agrees: "The case for perfect information [making scores on external examinations available rather than just whether the individual passed or failed] would appear to be strong, if not airtight: for most plausible degrees of heterogeneity, egalitarianism, and pooling under decentralization, perfect information not only raises GDP, but also social welfare (1994, p. 970)."
5. **Cover almost all secondary school students.** Exams for a set of elite schools, advanced courses or college applicants will influence standards at the top of the vertical curriculum, but will probably have limited effects on the rest of the students. The school system as a whole must be made to accept responsibility for how students do on the exams. A single exam taken by all is not essential. Many nations allow students to choose which subjects to be examined in and offer high and intermediate level exams in the same subject.
6. **Assess a major portion of what students studying a subject are expected to know or be able to do.** It is, however, not essential that the external exam assess every instructional objective. Teachers can be given responsibility for evaluating dimensions of performance that cannot be reliably assessed by external means.

## **1.2 Why and How are CBEEES Hypothesized to Increase Achievement?**

National or provincial curriculum-based external exit examinations systems (CBEEES) improve the signals of achievement available to colleges and employers and this is likely to induce them to give academic achievement greater weight when they make admission and hiring decisions. Rewards for study and learning should grow and become more visible.

**Effects on Students:** Rewards are necessary because learning is not a passive act; it requires the time and active engagement of the learner. Students have many other uses for their time and attention, so learning is costly for them. The intensity of their investment in learning depends on a comparison of benefits--intrinsic and extrinsic rewards for learning--to costs. A rise in the benefits of learning increases student effort and learning [see Appendix A for a mathematical presentation of this theory].

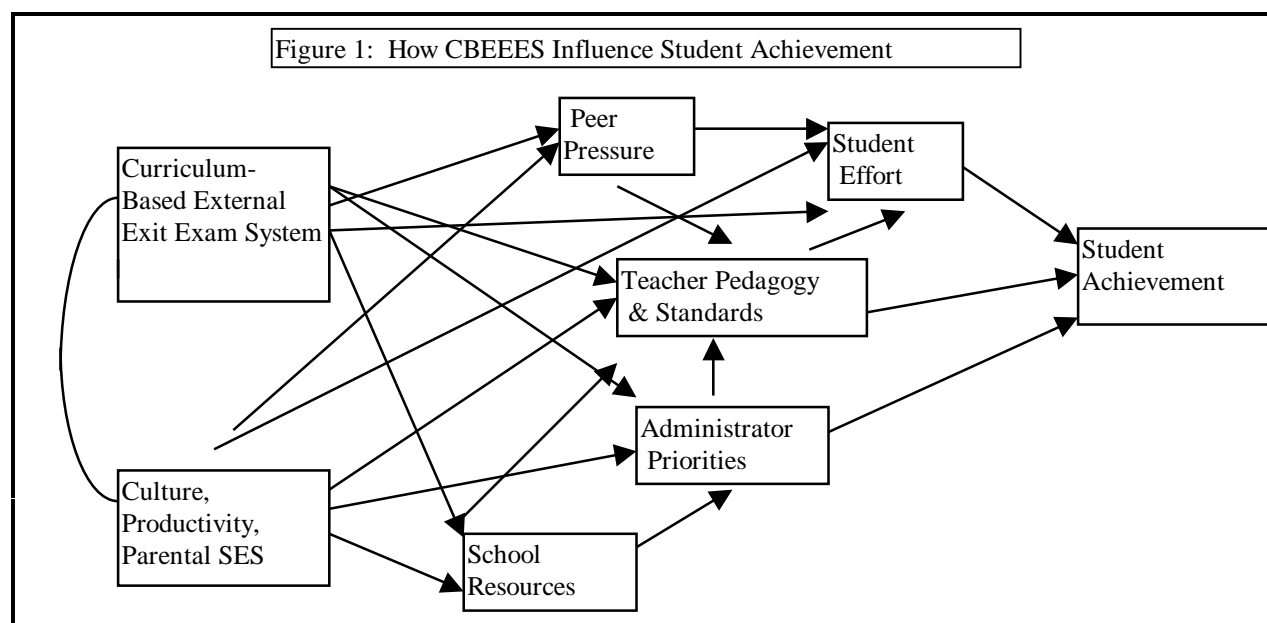
CBEEES should also shift attention towards measures of absolute achievement and away from measures of relative achievement such as rank in class and teacher grades. Advocates of CBEEES hope that they will reduce peer pressure against studying. Interviews I have conducted during 1996 and 1997 with middle school students in Collegeville, a small city dominated by two universities, indicate that most students (males especially) internalize a norm against “sucking up” to the teacher. How does a student avoid being thought a “Suck up?” He:

- Avoids giving the teacher eye contact
- Does not raise his hand in class too frequently, and
- Talks or passes notes to friends during class (this signals that you value friends more than your rep with the teacher).

Steinberg, Brown and Dornbush conclude similarly that “The adolescent peer culture in America demeans academic success and scorns students who try to do well in school (1996, p.19).” My conversations with Swedish students sometimes generate similar anecdotes.

Why are the studious called *suck ups*, *dorks* and *nerds*? In part, it may be because, grading exams on a curve means that study effort by one student tends to make it more difficult for others to get top grades. When exams are graded on a curve or college admissions are based on rank in class, the joint welfare of students is maximized if no one puts in extra effort. In the repeated game that results, side payments--friendship and respect--and punishments--ridicule, harassment and ostracism--enforce the cooperative "don't study" solution. If, by contrast, students are evaluated relative to an outside standard, they no longer have a personal interest in getting teachers off track or persuading each other to refrain from studying. Peer pressure demeaning studiousness should, in theory at least, diminish.

Parents, school administrators and teachers are also influenced by comparisons of the benefits and costs of focusing school resources and policies on academic achievement. When a CBEEES is in place, exam results displace social class as the primary determinant of school reputations and this in turn should induce school staff to give enhanced learning higher priority. Teachers will upgrade curricula and assign more homework and parents will demand better science labs and more rigorous teaching. School administrators will be pressured to increase the time devoted to examination subjects and hire more qualified teachers. The theory sketched above is elaborated in the next section and presented in its full mathematical detail in Appendix A. The many paths by which CBEEES are hypothesized to influence student achievement are illustrated in Figure 1.



## II. TESTABLE HYPOTHESES: IMPACTS OF CURRICULUM BASED EXTERNAL EXIT EXAMS

**Students:** The theory sketched above (and in the Appendix) predicts that:

H.1—Curriculum-based external exit external examinations will result in higher achievement. The effects should be strongest the year prior to the external examination, but they should reach down to 7<sup>th</sup> and 8<sup>th</sup> grade though maybe not down to the early years of primary school.

H.2--External exams will result in higher achievement, even when student characteristics, school resources, curriculum, teacher qualifications and teaching techniques are held constant.

Students are expected to try harder partly because CBEEES increase the rewards for achievement and partly because CBEEES are hypothesized to decrease peer denigration of studiousness.

**Parents:** Curriculum-based external exams are also hypothesized to change the incentives faced by parents. As a result, they are expected to put more energy into getting their children to study regularly.

H.3--External exams will induce parents to spend more time talking with their children about school and result in student's perceiving their parents to be more interested in their doing well in examination subjects.

Opponents of external exams argue that focusing student attention on extrinsic rewards for learning will weaken student's intrinsic motivation to learn. George Madaus's list of possible negative effects includes "test scores come to be regarded by parents and students as the main, if not the sole, objective of education" and the result is "undue attention to material that is covered in the examinations, thereby excluding from teaching and learning many worthwhile educational objectives and experiences (1991b p. 7)."

If they are right, students in systems with external exams should be less likely to read for pleasure or watch science programs like NOVA and Nature. Therefore, hypothesis # 4 is that:

H.4--Students will spend

- \* less time watching science documentaries on TV and
- \* less time reading for fun.

**School Administrators:** Local school administrators make hundreds of decisions that influence academic expectations and program quality (eg. homework guidelines, whether to retain a popular but not very effective teacher, etc.). In many countries schools are expected to achieve a host of often conflicting objectives: fostering self-esteem, providing counseling and supervising extra-curricular activities, musical training, health services, community entertainment (eg. interscholastic sports. These other goals require additional staff and different kinds of staff. They may not be served by hiring teachers with a strong background in calculus or chemistry.

When there is no external assessment of academic achievement, students and their parents benefit little from administrative decisions that opt for higher standards, more qualified teachers or a heavier student work load. The immediate consequences of such decisions--higher taxes, more homework, having to repeat courses, lower GPA's, complaining parents, a greater risk of being denied a diploma--are all negative.

When student learning is not assessed externally, the positive effects of choosing academic rigor are negligible and postponed. If college admission decisions are based on rank in class, GPA and aptitude tests, not externally assessed achievement in secondary school courses, upgraded standards will not improve the college admission prospects of next year's graduates. Graduates will probably do better in difficult college courses and will be more likely to get a degree, but that benefit is uncertain and far in the future. Maybe over time the school's reputation and, with it, the admission prospects of graduates will improve because the current graduates are more successful in local colleges. That, however, is even more uncertain and postponed. Publishing data on proportions of students meeting targets on standardized tests probably speeds the process by which real improvements in a school's performance influence it's local reputation. However, other indicators such as SAT test scores, proportions going to various types of colleges and the socioeconomic background of the students tend to be more prominent. As a result, school reputations are determined largely by things that teachers and administrators have little control over: the socio-economic status of the student body and the proportion of graduates going to college.

In the U.S. few employers pay attention to a student's achievement in high school or the school's reputation when they make hiring selections (Bishop 1989, 1993, Hollenbeck and Smith 1984. As a result, students who study hard are not immediately rewarded with higher wage rates. Their greater competence is not fully recognized with higher wage rates until more than a decade after they graduate. Consequently, higher standards do not benefit students as a group, so parents as a group have little incentive to lobby strongly for higher teacher salaries, higher standards and higher school taxes.

External exams in secondary school subjects change the signalling environment. Hiring better teachers and improving the school's science laboratories now yields a visible payoff to students passing the external exams and being admitted to top colleges. School reputations will now tend to reflect student academic performance rather than the family background of the community or the success of football and basketball teams.

Hypothesis # 5, therefore, is that:

H.5--External exams will cause priorities to shift in favor of achievement in examination subjects and away from inter-scholastic sports, band and other activities intended to make school fun and entertain the public. Administrators and school boards will be induced:

- (A) to improve the school's science laboratories (if science is an examination subject) and other facilities that contribute to learning in examination subjects.
- (B) to offer additional courses in examination subjects and scale back offerings outside the core academic program.
- (C) to increase the share of the school week devoted to examination subjects (when this is a local decision),
- (D) to lengthen the school day and school year (when this is a local decision),
- (E) to offer accelerated/enriched math and science courses.
- (F) to use specialist teachers to teach examination subjects.
- (G) to hire teachers with a thorough background in the field
- (H) to reduce class size in examination subjects.
- (I) to give teachers additional preparation time.
- (J) to pay higher salaries.
- (K) to spend more per pupil.

Where students and parents choose their secondary school and state subsidies follow the student, the incentive effects of CBEEES are magnified. In countries that have both school choice and a CBEEES, newspapers typically publish league tables reporting examination results by school. These results have major effects on enrollment applications the following year. Marginal instructional costs are typically below state aid per student, so schools at the top of the league table often expand (sometimes by bringing in temporary classrooms), forcing the schools with poor results to shrink and lay off staff.

H.6--External exams will induce larger shifts in the priority given academics when parents are able to choose which school their child attends and dollars follow the student.

**Teachers:** Thirty percent of American teachers say they "feel pressure to give higher grades than students' work deserves" and "feel pressure to reduce the difficulty and amount of work you assign" (Peter D. Hart Research Associates, 1994). Under a system of external exams, teachers and local school administrators

lose the option of lowering standards in order to lower failure rates and raise self-esteem. Their response will be to strive to prepare their students for the external exam. Therefore, hypothesis # 7 is that:

H.7--External exams will induce teachers

- (A) to set higher standards,
- (B) to assign more homework,
- (C) to increase the number of experiments that students do in science class,
- (D) to have students solve mathematics problems alone rather than in groups,
- (E) to give more quizzes and tests,
- (F) to increase their use of other teaching strategies which they believe improve exam performance,
- (G) to de-emphasize trying to entertain students and
- (H) to pay less attention to non academic goals such as self esteem, good discipline and low absenteeism.

Some educators argue that external exams can have negative effects on teaching. It is argued, for example, that "preparation for high stakes tests often emphasizes rote memorization and cramming of students and drill and practice teaching methods" and that "some kinds of teaching to the test permits students to do well in examinations without recourse to higher levels of cognitive activity (Madaus 1991 p. 7-8)."

The assumption of opponents appears to be that the tests developed by individual teachers for use in their class are better than examinations developed by the committees of teachers that would have responsibility for developing provincial or national examinations. To the contrary, the tests that teachers presently develop for themselves are generally of low quality. Fleming and Chambers (1983) study of tests developed by high school teachers using Bloom's taxonomy of instructional objectives found that "over all grades, 80% of the items on teachers' tests were constructed to tap the lowest of the taxonomic categories, knowledge (of terms, facts or principles)"(Thomas 1991, p. 14). Rowher and Thomas (1987) found that in colleges fully 99 percent of items on instructor developed tests in American history required the integration of ideas, while only 18 percent of junior high school and 14 percent of senior high school test items required such integration. Secondary school teachers test low level competencies because that is what they teach. Students do not take state mandated tests in history, so poor history teaching cannot be blamed on standardized tests. More evidence is needed on this issue, so tests will be conducted of the following hypothesis:

H.8--External exams will cause teachers to focus on teaching facts and definitions; not the scientific process. Students will conduct fewer experiments in science class and computation will be stressed in mathematics. Students will report that lots of memorizing is essential to learning the subject. The frequency of reasoning tasks will go down.

CBEEES advocates argue to the contrary that well designed external examinations that are graded by teachers will improve instruction. In May 1996 I interviewed a number of activists in the Alberta Teachers Union about the examination system in Alberta Canada. Even though the union and these



teachers all opposed the exams, they universally reported that serving on grading committees was “...a wonderful professional development activity (Boh1996).” Having to agree on what constituted excellent, good, poor, and failing responses to essay questions or open ended math problems resulted in a sharing of perspectives and teaching tips that most found very helpful.

### **III. DO CBEEES INCREASE ACHIEVEMENT? A LOOK AT THE EVIDENCE.**

The hypothesis that curriculum-based external exit examination systems improve achievement will be tested by comparing nations and provinces that do and do not have such systems. Four different data sets will be examined: science and mathematics achievement of 7<sup>th</sup> and 8<sup>th</sup> graders in the 40 nation Third International Math and Science Study, the reading literacy of 14 year olds in the 1991 International Association for the Evaluation of Educational Achievement's (IEA) Reading Literacy Study, and science, mathematics and geography scores of 13 year olds on the International Assessment of Educational Progress (IAEP) for 16 nations and for 9 Canadian provinces. The theory predicts that CBEEESs influence societal decisions about education spending, administrator decisions about school priorities, teacher's decisions about standards and pedagogy and student decisions about studying. Much of the ultimate impact of CBEEESs on student achievement derives from the changes they induce in school priorities and teacher pedagogy. In section 3 of this paper, the objective is to assess the **total** effect of CBEEESs on achievement (the sum of all the paths leading from CBEEES to student achievement in Figure 1). Estimates of the total effects of CBEEESs are obtained from a reduced form model that controls for parental socio-economic status, national productivity levels and national culture, not the endogenous administrator, teacher and parent behaviors. Section 4 of the paper presents models of the paths leading out of the CBEEES box in Figure 1. The relationship between CBEEES and the resources devoted to K-12 schooling, administrative policies and priorities and teacher pedagogy and standards are studied both in a 42 nation cross section and by comparing Canadian provinces with and without CEEES.

#### **3.1 Third International Mathematics and Science Study--TIMSS:**

TIMSS provides 1994-95 data on math and science achievement of 7th and 8th graders in 39 countries. Comparative education studies, government documents and education encyclopedias were reviewed and education ministry officials, embassy personnel and Cornell graduate students from the country were interviewed to determine which of the TIMSS nations have curriculum-based externally-set exit examinations in secondary school.<sup>1</sup> Twenty-two national school systems were classified as having CBEEES for both subjects in all parts of

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<sup>1</sup> Appendix B provides a bibliography of the documents and individuals consulted when making these classifications. The TIMSS report's information about examination systems does not distinguish between university admissions exams and curriculum-based exit exams, so its classifications are not useful for this

the country: Austria, Bulgaria, Columbia, Czech Republic, Denmark, England, Hong Kong, Hungary, Ireland, Iran, Israel, Japan, Korea, Lithuania, the Netherlands, New Zealand, Russia, Scotland, Singapore, Slovak Republic, Slovenia and Thailand. Three countries--France, Iceland and Romania--had CBEEES in mathematics but not in science. Five countries--Australia, Canada, Germany, Switzerland and the United States--had CBEEES in some provinces but not in others. Norway has regular exit examinations in mathematics, but examines science only every few years. Latvia had an external examination system until very recently, so it was given a .5 on the CBEEES variable. The countries classified as not having a CBEEES in either subject were Belgium (both Flemish and French speaking systems), Cyprus, Greece, Philippines, Portugal, Spain and Sweden. Following Madaus and Kelleghan (1991), the university entrance examinations in Greece, Portugal, Spain, Cyprus and the ACT and SAT in the U.S. were not considered to be CBEEES. University entrance exams should have much smaller incentive effects because students headed into work do not take them and teachers can avoid responsibility for their students' exam results by arguing that not everyone is college material or that examiners have set an unreasonably high standard to limit enrollment in higher education.

Figures 2 and 3 array the 40 TIMSS countries by the science and mathematics achievement of their 13 year olds. The US ranks # 15 in science and # 31 in mathematics. The gaps between the vertical grid lines represent one U.S. grade level equivalent—the difference between 7<sup>th</sup> and 8<sup>th</sup> grade TIMSS test score means for the U.S. Achievement differentials across nations are very large. In science Singapore, Korea, Bulgaria and Flemish Belgium are more than 1 GLE ahead of the US and Columbia, Phillipines, Lithuania, Romania and Portugal are more than 3 GLEs behind. In mathematics Singapore, Korea, Japan and Hong Kong are 4 or more grade level equivalents ahead of the U.S., while Columbia, Phillipines and Iran are more than 3 GLEs behind. The countries represented by a solid black bar in the figures have a curriculum-based external exit exam in the subject. Countries represented by white bars do not. Note that the countries with a CBEEES in the subject tend to have higher TIMSS scores.

Regression Analysis: The mean 8<sup>th</sup> grade science and mathematics test scores were regressed on average per capita gross domestic product in 1987 and 1990 deflated by a purchasing power parity price index, a dummy for East Asian nation and a dummy for CBEEES.<sup>2</sup> The results presented in Table 1 indicate that test scores are significantly higher in more developed nations, East Asian nations and in nations with a CBEEES in the subject.

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exercise. The Philippines, for example, is classified as having external exams by the TIMSS report, but it's exams are university admissions exams similar to the SAT. South Africa was excluded because its education system was disrupted for many years by boycotts that were part of the campaign to end apartheid. Kuwait was excluded because of the disruption of its education system by the Iraqi invasion and the Gulf War. Iran was excluded because data on private school market share was not available and the disruptive effects of the clerical administration of the country.

<sup>2</sup> TIMSS studied the two grades with the largest number of 13 year olds. The grade included in the regression was the upper grade of the two studied. In Sweden, Norway and Denmark 7<sup>th</sup> grade was used

The analysis of achievement at a particular grade level may be biased, however, by differing policies regarding grade retention, age of school entry and which grade was chosen for assessment. CBEEES, for example, might be associated with high rates of grade retention.<sup>3</sup> Therefore, a preferable dependent variable is a measure of student achievement at some fixed age. The third and fourth rows of each panel present estimated models predicting the median test score for each nation's 13 year olds (Beaton et al, 1996a,b, Table 1.5). For countries not included in this table, the 13 year old median was estimated by age adjusting the 7th and 8th grade means.<sup>4</sup> Switching to the age constant achievement somewhat reduces the estimated impact of the CBEEES but the effects remain statistically significant. Using two tail *t* tests, the CBEEES coefficient has a *P* = .08 in the mathematics model and a *P* = .01 in the science model. The estimated impacts are substantively important: **1.3** U.S. grade level equivalents in science and **1.0** U.S. grade level equivalents in mathematics.

One of the ways CBEEES may improve achievement is by inducing greater social investments in education. Row 4 presents results of regressions that add the share of GDP spent on education to the standard model. Coefficients on this variable are positive for both outcomes and significantly so for science. The estimated impact of spending is modest, however. A one percentage point increase in the share of GDP devoted to education increases the science achievement of 13 year olds by one half a grade level equivalent.

### 3.2 the IEA Study of Reading Literacy

The International Association for the Evaluation of Educational Achievement's (IEA) conducted a study of Reading Literacy of 14 year olds in 1990-91. The bottom panel of Table 1 presents an identical analysis of IEA reading achievement data. To avoid the problems of differing school entry ages and grade retention policies, the age standardized reading scores provided in Appendix E of Elley (1995) have been used in the analysis. The IEA study defined and measured three different types of reading literacy—narrative, expository and document—and an average of the three scores is the dependent variable. The specification is the same as that

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because children start school at a later age. In England, Scotland and New Zealand the 9<sup>th</sup> grade was used because children start grade 1 a year earlier than in most nations.

<sup>3</sup> School attendance is not universal at age 13 in some of the less developed countries participating in TIMSS. TIMSS publications do not report age specific school enrollment rates but they do report an indicator that sets a lower bound on age specific school enrollment rates--the proportion of the nation's 13 year olds who were in one of the two grades tested. The developing countries with rates below 80 were Columbia (45%), Iran (72%), Portugal (76%), Romania (76%) and Thailand (78%) [Beaton et al, 1996, Table A3].

<sup>4</sup> The Philippines, for example, had a math score mean of 399 in 8<sup>th</sup> grade and a mean of 386 in 7<sup>th</sup> grade. The mean age of 8<sup>th</sup> graders was 14 and the mean age of 7<sup>th</sup> graders was 12.9. The math score for 13.5 year olds was estimated by interpolation between 7<sup>th</sup> and 8<sup>th</sup> grade means.  $\text{Math}_{13.5} = 386 + (399 - 386) * ((13.5 - 12.9) / (14 - 12.9))$ .

used to study science and math achievement. Here the exam variable is an average of the math and science CBEEES dummy variables used in the analysis of TIMSS data. The results are similar as well. Diploma exams and per capita GDP have significant positive effects on reading achievement. The share of GDP spent on education has no significant effect on reading achievement.

### 3.3 Effect of the Size of the Private School Sector

The hypothesis that a large private school sector instigates a competitive environment that makes all schools better is tested in the bottom two rows of each panel. Row 4 presents the results of adding the share of primary and middle school students who attend private schools to the model. Adding the private share leaves the coefficients on CBEEES unchanged and does not improve model fit. The private sector size variable has inconsistent and statistically insignificant effects on average achievement levels. In the models of science and reading achievement, the point estimate is negative. In the math equation it is positive but tiny. Clearly there is no linear relationship between the size of the private school sector and student achievement.

I also tested for a non-linear relationship. This was accomplished by allowing the slope of the relationship between private sector share and achievement to shift at some arbitrary kink point (ie. including a spline). Two separate slopes were estimated; one for the region from zero to .11, the current U.S. private school enrollment share, and one for the range from .11 to 1.0. The kink point of .11 is above the median of the variable and slightly below the mean, which is .139. The coefficients on the lower range are all significantly negative. They imply that countries that lack any private schools such as Sweden will tend to have a more than one grade level equivalent achievement advantage over countries like the U.S. with modest size private sectors when other things—GDP, Asia and Exam systems—are held constant. The upper region coefficient from the mathematics regression is statistically significant and positive. This suggests that the large size of the private school sector in Belgium, Hong Kong and the Netherlands may be one of the reasons why math achievement is high in these three countries.<sup>5</sup>

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<sup>5</sup> There are two possible reasons for this non-linear relationship--one causal, the other not. The causal explanation proposes that a growing private school sector will weaken support of public schools causing them to be under funded. If there are no alternatives to public schools, activist parents will “Voice” their concern by running for PTA president or the school’s board of governors. Their pressure, it has been hypothesized, keeps the schools first class. When private schools are an option for most parents, the activists “Exit” and their positive influence on the quality of the public school may be lost. The only way to avoid this fate is to tie the fortunes of the two sectors together by requiring students in both sectors to take the same courses and the same exams and tying the subsidy of private school student to the subsidy of public school students. This is what Belgium, Hong Kong and the Netherlands have done and it has resulted in a very large private sector. The other explanation proposes that unsubsidized private sectors [such as the one that has captured 11% of the market in the U.S.] spring up when the public schools do a poor job. If public schools are of uniformly high quality, private schools have no market niche to fill. If the nation chooses to fund private schools on the same footing as public schools, they end up with over half of the market and their pressure forces the public schools to become better.

### 3.4 The Impact of CBEEES on Inequality of Achievement

Policy makers are also interested in knowing whether CBEEES effect the variance of student achievement as well as the level. To address that question, models were estimated predicting the standard deviation of student achievement for the 39 nations that participated in TIMSS. The specification was, with just one exception, the same as that used to predict achievement levels. In order to deal with possible distorting effects of floors and ceilings on the TIMSS achievement scales, the level of achievement was included as an independent variable along with per capita GDP and dummy variables for East Asia and for a CBEEES. The results are presented in the top panel of Table 2. CBEEES neither increase nor decrease the variance of student achievement. Per capita GDP and the dummy for East Asian nation have no effect either. The level of achievement is the only variable with a statistically significant relationship with the standard deviation of achievement.

### 3.5 Analysis of the 1991 International Assessment of Educational Progress

**Science and Mathematics:** The 1991 International Assessment of Educational Progress (IAEP) is the third data set in which CBEEE effects can be tested. Fifteen nations are available for the analysis: England, France, Hungary, Ireland, Israel, Emilia Romagna/Northern Italy, Korea, Portugal, Scotland, Slovenia, Soviet Union, Spain, Switzerland, Taiwan and the United States.<sup>6</sup> In IAEP, schools were first sampled, then students within schools. Sampling frames generally excluded separate schools for special education students and often very small schools as well. Israel assessed only its Hebrew speaking schools, The Soviet Union assessed Russian language schools in 14 of the nation's 15 republics. Switzerland's assessed 15 of 26 cantons. A school's likelihood of selection was roughly in proportion to its estimated number of 13 year olds. In most countries school non-response rates were extremely low. They were zero in Hungary, Slovenia, Korea and Taiwan and 3 percent in Israel and the Soviet Union. The countries with high non-response rates were Switzerland (17 %), Emilia Romagna (18%), Scotland (19%), USA (21%) and England (48%). When sampled schools declined to participate an alternate was selected from the same stratum (IAEP 1992c). Random samples of 30 to 34 thirteen year olds were selected from each school. Half were assigned to the mathematics assessment and half assigned to the science assessment. The average percent correct (adjusted for guessing) for 13 year old students was regressed on the same set of variables as in the analysis of the TIMSS data. The results are presented in the bottom panel of Table 2.

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<sup>6</sup> Four IAEP nations were not included in the analysis: China and two provinces in Brazil because the schools included were not representative of the country as a whole, Mozambique because of a recent civil war and Jordan because of low levels of industrialization.

For mathematics the effect of curriculum-based external exams is highly significant and quite large. Since the U.S. standard deviation was 26.8 percentage points in mathematics, the CBEEE effect on math was more than one-half of a U.S. standard deviation or about 2 U.S. grade level equivalents. CBEEEs had a smaller non-significant effect on science achievement. East Asian students scored significantly higher than students in Europe and North America. Coefficients on per capita GDP were positive but not statistically significant.

**Geography:** Nine of the countries in the IAEP study assessed geography as well as mathematics and science. The countries participating in the geography assessment were Canada, Hungary, Ireland, Korea, Scotland, Slovenia, Soviet Union, Spain and the United States. Canada collected sufficient data to allow valid comparisons between provinces and between the Anglophone and Francophone school systems of the five provinces with dual education systems. Some of these provinces have CBEEEs and others do not so including the Canadian provincial data in the study substantially increases the power of our tests for the effects of exams (IAEP 1992d).

Regressions were estimated predicting adjusted country means using the same specifications as above.<sup>7</sup> Per capita GDP had the wrong (a negative) sign, so preferred specifications are those which do not include this variable. In the preferred model, curriculum based exams have a significant effect on geography achievement. The effect appears to be roughly 20 percent of a U.S. standard deviation.

These results are consistent with the causal hypotheses presented above. Causation is not proved, however, because other explanations can no doubt be proposed. Other sources of variation in curriculum based exams need to be analyzed. Best of all would be studies that hold national culture constant. Bishop, Mane and Moriarty (1997) have found that, when socio-economic background is held constant, students from New York State, the only US state with a CBEEES, out perform students in other states on the NAEP math assessment and on the SAT-I. This paper presents a comparison of math and science achievement of Canadian students living in provinces with curriculum-based diploma examinations to comparable students in provinces without such examinations.

### 3.5--Comparing Canadian Provinces

In 1990-91, the year the IAEP data was being collected, Alberta, British Columbia, Newfoundland, Quebec and Francophone New Brunswick had curriculum-based provincial examinations in English, French, mathematics, biology, chemistry, and physics during the senior year of high school. These exams accounted for

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<sup>7</sup> The following procedure was implemented to standardize for differences in socio-economic background across countries in the analysis of Geography. Mean geography knowledge for students from families with varying numbers of books in the home was available. An average of percent corrects was then calculated with male and female students with 10 or fewer books each given a weight of .1 and the 25-100 books and over 100 books predictions for each gender each getting a weight of .2.

50 percent of that year's final grade in Alberta, Newfoundland and Quebec and 40 percent in British Columbia. The other provinces did not have curriculum-based provincial external exit examinations in 1990-91. Ontario eliminated them in 1967, Manitoba in 1970 and Nova Scotia in 1972. Anglophone New Brunswick had provincial exams in language arts and mathematics but exam grades were not reported on transcripts or counted in final course grades. Canadian provincial exams are medium stakes, not high stakes tests. They influence grades but passing the examination is not essential for graduation. Employers appear uninterested in exam scores. Job application forms do not request that applicants report exam scores or grades.

The principals of schools sampled by IAEP completed questionnaires describing school policies, school resources and the qualifications of 8th grade mathematics and science teachers. Students completed a brief questionnaire that asked about books in the home, number of siblings, language usually spoken at home, home availability of calculators and computers, hours of TV, hours doing homework, pleasure reading, watching science programs on TV, parental oversight of school work and teaching methods of teachers.

The effect of curriculum-based provincial exit exams taken by 12th graders on achievement of Canadian 13 year olds was examined by estimating models predicting achievement using schools as observations. The data set comprises 1362 Canadian schools. The dependent variable is the school mean percent correct with adjustments for guessing. It is defined as the (number of correct answers minus .25 times the number of answered questions) all divided by (.75 times the number of items on the test). Adjusted for guessing, the students got an average of 47.2 percent in math and 57.3 percent in science. The standard deviation across Canadian 13 year olds is 24 points for the math score and 20 points for science score.

The first row in the top two panels of Table 3 presents simple regressions containing no controls for school characteristics. Row 1 tells us that students in provinces with exam systems scored 6.2 points higher in math and 3.5 points higher in science. Adding controls for school type (school includes elementary grades, school includes K-11<sup>th</sup> grade, Francophone school) in row 2 lowers the EXAM effect to 4.1 points for math and 2.6 points for science. Adding additional controls for three types of school governorship in rows 3 lowers the EXAM effect to 3.5 points for math and 2.5 points for science.

Now let us examine what happens in row 4 when controls are added for the demographic background of the school's student body--school means for books at home, number of siblings and proportion of students whose home language is different from the language of instruction and size of the school. In this model, schools in Exam provinces are 5.1 points higher in math and 2.6 points higher in science. The variables added to the model in row 5 and 6 are hypothesized to be influenced by the existence of external exams. Consequently, row 4 presents our best estimate of the total impact (including indirect effects) of having a provincial exam in the subject at the end

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of secondary school on IAEP test scores at age 13. The effect of provincial exams is about one-half of a U.S. grade level equivalent.

The gains in mean achievement generated by exam systems do not come at the expense of greater inequality. Exam provinces have less variability of achievement across schools. The variance of school mean science achievement is smaller in Alberta, British Columbia and Quebec than in any other province. For math achievement the variance was lowest in New Brunswick, British Columbia, Saskatchewan, Quebec and Alberta. Regressions predicting the standard deviation of achievement among students at a school were run and within-school standard deviations for science achievement are smaller in exam provinces (Bishop 1998).

***Is the EXAM effect causal?*** One possible skeptical response to a causal interpretation of these findings is to point out that omitted variables and/or selection effects may be biasing the coefficient on the CBEEES indicator variable. Maybe the people of Alberta, British Columbia, Newfoundland, Quebec and Francophone New Brunswick--the provinces with exam systems place higher priority on education than the rest of the nation.<sup>8</sup> Maybe this trait also results in greater political support for examination systems. If so, we would expect that schools in the exam provinces should be better than schools in other provinces along other dimensions such as discipline and absenteeism, not just by academic criteria. The theory developed in Appendix A predicts, to the contrary, that exam systems induce students and schools to redirect resources and attention to learning/teaching exam subjects and away from the achievement of other goals such as low absenteeism, good discipline and lots of computers. These competing hypotheses are evaluated in the bottom panel of Table 3. Contrary to the "provincial taste for education" hypothesis, principals did not report significantly fewer discipline problems and were significantly more likely to report absenteeism problems.

***Adding Endogenous Student Behavior and School Policy Variables::*** The fifth row of the top two panels has two additional control variables--calculator availability and computer use. Having a calculator at home and using computers for school work is associated with higher math achievement but not higher science achievement. Including these variables in the model has little effect on the CBEEES coefficient. The models presented in row 6 of each panel add a full set of endogenous school policy, school input and student behavior variables [see table notes for list]. Consequently they provide a test of whether CBEEES have direct effects on achievement when endogenous school policies and inputs, homework assignments and TV watching are all held

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<sup>8</sup> This will seem like a strange idea to people who know Canada. With the exception of Alberta and British Columbia, these provinces have little in common. Historically they do not seem to have valued education more than the rest of Canada. Adult literacy is lower on average in these four provinces than in the rest of Canada. Newfoundland is quite poor and has significantly lower levels of adult literacy than the rest of Canada. The adult literacy study placed Quebec in the middle of the pack along with Ontario, Nova Scotia and New Brunswick. Two of the top four provinces with respect to adult literacy have exam systems and two do not. Saskatchewan is number one when it comes to adult literacy, yet it's 13 year olds lag substantially behind students from Alberta and British Columbia in mathematics and science.



constant. For science, the CBEEES coefficient is still positive, but it is very small and no longer statistically significant. Apparently, just about all of the effects of CBEEESs on science learning operate through school policies and indicators of student time allocation (hours doing homework and hours watching TV). For mathematics, however, there is a substantial and significant direct effect of CBEEES on math achievement even when student time allocation is held constant.

#### **IV. IS PARENT, ADMINISTRATOR AND TEACHER BEHAVIOR DIFFERENT IN THE PRESENCE OF CURRICULUM-BASED EXIT EXAMINATIONS? A LOOK AT THE EVIDENCE.**

Are the teachers, school administrators and parents in nations and provinces with CBEEESs behaving differently from their counterparts in nations and provinces that lack a CBEEES? This will be examined by estimating models predicting mean levels of these behaviors in a sample of 42 nations most of whom participated in TIMSS and in IAEP data on a sample of 1360 Canadian middle schools. The cross section analysis of schooling inputs and indicators of student effort in 42 nations employs the same specification as that used in the cross section analysis of TIMSS data on student achievement. It contains three variables: per capita GDP, a dummy variable for East Asia and a dummy variable for CBEEES. Results are presented in Tables 4, 5 and 6.

The model that tested for the effects of CBEEES in Canadian data was identical to the one presented in row 4 of Table 3. It contained 11 variables: logarithm of the mean number of books in the home, the mean number of siblings, the proportion of the school's students whose home language was different from the language of instruction, logarithm of the number of students per grade in the school and dummies for schools run by a locally elected Catholic (or Protestant) school board, independent secular and non-secular schools, schools with primary grades, schools that include all grades in one building, French speaking schools, and a dummy for EXAM province. Results are presented in Table 7.

The discussion to follow will be organized around the hypotheses set forth in section 2. I begin by examining Hypothesis #5—the impact of CBEEES and per capita GDP on indicators of school quality such as spending, class size, teacher salaries and qualifications (X in the theory in Appendix A). I then turn to issues of teacher pedagogy—Hypotheses #7 and #8—(indicators of both X and E in our theory). The section concludes with an analysis of how student and parental attitudes and behavior are affected by per capita GDP and CBEEES.

##### **4.1—Education Spending, Teacher Qualifications and Salaries—Hyp # 5-F to 5-K**

The theory presented in Appendix A predicts that rich countries will buy higher quality schooling inputs [more X] than poor countries. The analysis of international cross section data on spending and teacher qualifications presented in the top panel of Table 4 supports this hypothesis. More developed countries invest a larger share of GDP in K-12 education and also set higher minimum qualifications for entry into secondary school teaching jobs.

Contrary to our hypothesis, however, CBEEES nations do not spend significantly more on K-12 schooling [see row 1 of Table 4] and, within Canada, class sizes are not smaller and time allowed for preparing lessons is not greater in CBEEES provinces [see first panel of Table 7]. On the other hand, indicators of teacher quality such as “having studied the subject in university,” 8<sup>th</sup> grade teachers being specialists in teaching their subject [rows 1-4 of Table 7] and the minimum qualifications for becoming a secondary school teacher are all significantly higher in CBEEES provinces and nations. There is also evidence from a cross section analysis of 17 advanced countries that relative pay levels are higher for secondary school teachers in CBEEES countries [see rows 3 and 4 of Table 4]. The higher pay has not, however, resulted in teachers becoming more satisfied with their status in society. Teachers in CBEEES nations perceived themselves to have lower relative status and were significantly more likely to report wanting to leave the profession if an opportunity came along [see the second panel of Table 4]. In addition, there is no tendency in the Canadian data for the teaching profession in CBEEES provinces to have a higher average level of experience. This suggests the possibility that exit rates from the profession may be higher in CBEEES nations. Why are better paid teachers less satisfied? Possibly because teachers who are part of a CBEEE system lose the ability to adjust their expectations for students to their own ability to teach the material. Students learn more, but teachers work harder and are under much greater stress because their ‘success’ or ‘lack of success’ as teachers is now more visible to others. This in turn helps explain why salaries are higher. Not only are more qualified teachers needed, they must receive extra compensation for the negative non-pecuniary characteristics (stress) of their job.

#### **4.2 The Quality of Physical Facilities—Hyp. 5-A**

Our theory predicts that facilities that are not believed to directly improve learning in externally examined subjects will not be better in CBEEES provinces. I would put athletic facilities, computers and libraries in this category. Facilities that are essential for high quality instruction in examination subjects such as science laboratories will be better in the presence of a CBEEES system.<sup>9</sup> The analysis of Canadian data supports this hypothesis. Science labs are significantly better in CBEEES provinces. Library books and computers, on the other hand, are no more prevalent in CBEEES provinces than in other provinces.

#### **4.3--Instructional Hours—Hyp. 5-B & 5-C**

When local school administrators have discretion over the amount of instruction time that is allocated to examination subjects, our theory predicts a CBEEES will induce them to allocate a more time to examination subjects. It is not clear whether the extra time will be obtained by extending the school day or by reducing time spent in study halls and subjects that are not externally examined. The analysis of Canadian data supports this hypothesis. Scheduled hours of instruction were 8 percent higher in CBEEES provinces for mathematics and 5 percent higher for science. Total hours in the school year did not increase, so it appears the extra math and science instruction came at the expense of something else [see row 5 and 6 of Table 7].

#### **4.4--Teacher Pedagogy—Hyp. 7 and 8.**

Some educators worry that external examinations will lower the quality of instruction. The fear is that science teachers will be induced to focus on facts and definitions not the scientific process. The discovery approach to teaching science—with students learning from experiments they conduct themselves--will be de-emphasized. In mathematics, computation will be emphasized to the exclusion of more advanced topics. Finally, students will start believing doing well in the subject depends on “memorizing the textbook and class notes.” The results of testing these hypotheses are given in Table 5 and 6 and in the second panel of Table 7.

The analysis of TIMSS data found, to the contrary, that students were less likely to believe that memorization was necessary to learn math and science in CBEEES nations. The difference was statistically significant for science. Teachers were significantly more likely to have students do experiments in class. The greater use of experiments to teach science was also found in the analysis of Canadian data. Teachers in CBEEES nations reported a significantly lower frequency of students doing reasoning tasks in mathematics but not in science. In mathematics the emphasis placed on computation of whole numbers by 8<sup>th</sup> grade teachers was significantly lower in Canadian provinces with CBEEES. There were no differences between provinces in the amount of time students spent working in groups to solve math problems or in the time spent doing math problems on their own. The overall conclusion from these comparisons is a resounding rejection of hypothesis 8. There is no evidence that the prospect of an external examination towards the end of secondary school causes the quality of instruction to decline in 8<sup>th</sup> grade. Along a number of dimensions there were no significant differences in pedagogy. Where CBEEES had a statistically significant relationship with an indicator of pedagogy, the quality of instruction was, in every case but one, higher in the CBEEES nations/provinces.

According to the Effective Schools literature, frequent quizzes and tests is one of the traits of effective schools. This leads one to predict that teachers would give quizzes and tests more frequently in CBEEES nations and provinces. The Canadian data supports this hypothesis, but the TIMSS data does not. Teachers in countries with CBEEES spend about the same amount of time “preparing and grading tests” and “reading and grading

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<sup>9</sup> Language labs are hypothesized to be better when listening and speaking skills are an important part of the external examination.

student work” as teachers in countries without a CBEEES. Students report they are given fewer tests in CBEEES nations. The only significant difference in the allocation of teacher time was the finding that teachers in CBEEES nations spent considerably more time meeting with and tutoring students.

#### **4.5--Student Effort—Homework versus TV and Hanging Out—Hyp. 7-B**

The theory presented in Appendix A was not able to sign the relationship between national wealth/productivity and student effort. The empirical findings, however, are unambiguous. Less homework is assigned in rich countries and a lot less is done. A doubling of GDP per capita reduces homework done by 4.2 hours per week or about one-third.

Our theory predicts that students will be expected to (and will in fact) work harder when they face a CBEEES sometime in the future. There is strong support for this hypothesis in the Canadian data. Students in CBEEES provinces spent significantly more time doing homework and significantly less time watching TV. In the TIMSS analysis, however, teachers in nations with a CBEEES did not assign more homework than teachers in other nations. Students in CBEEES nations reported doing less homework. In fact, when the differences on all three homework variables are added together, students in CBEEES nations say they spend about 4 fewer hours a week doing homework, a reduction of about one-third relative to the international mean. They also reported spending an extra 5.6 hours a week watching TV, playing video games and playing or talking with friends. There were no differences in time spent playing sports. Apparently, the image of the over worked Japanese student preparing for examination hell does not characterize most CBEEES nations, at least not in 7<sup>th</sup> and 8<sup>th</sup> grade.

This finding suggests a need to revise the theory. One place where a revision may be needed is the assumption that teachers do not use direct measures of student effort such as homework assignments turned in as part of their grading formula. There might be two kinds of student effort—one invisible to teachers and the other visible and part of the teacher’s grade. When a CBEEEE becomes the only signal of student achievement, the teachers might no longer be able to induce students to hand in long homework assignments. Under this assumption a CBEEES might increase invisible student effort while simultaneously decreasing visible student effort. This did not happen in Canada because the external exam results were only a part of the final grade. TIMSS has data on how teachers evaluate students so it should be possible to investigate this hypothesis.

#### **4.6 The Hypothesized Damaging Effects of External Rewards tied to External Exams—Hyp. 4.**

Critics of externally set curriculum-based examinations predict that they will cause students to avoid learning activities that do not enhance exam scores. This hypothesis was operationalized by testing whether exam systems were associated with less reading for pleasure, less watching of science programs like NOVA and Nature and fewer students having positive attitudes toward the subject. None of these hypotheses is supported. In the

TIMSS data liking math and science and time spent reading for pleasure was unrelated to the existence of a CBEEES. In Canadian data students in exam provinces spent significantly more time reading for pleasure, significantly more time watching science programs on TV, while watching less TV overall. Student attitudes were also more positive. Students in CBEEES provinces were significantly more likely to believe that “science is useful in everyday life.” With respect to beliefs that “math is useful in solving everyday problems,” there were no differences between CBEEES and non-CBEEES provinces. Finally, students in exam provinces were not more likely to say that extrinsic rewards (eg. getting a better job) would result from doing well in math and science. Their view apparently reflects the Canadian reality. An examination of a small sample of job applications obtained from Canadian employers, revealed that they typically do not ask for information on exam grades or GPA.

#### **4.7—Impacts on the Behavior of Parents—Hyp. 3.**

Information on parental attitudes and involvement with their children’s studies was available only in the IAEP data on Canada. Parents in CBEEES provinces were significantly more likely to talk to their children about their math and science classes and their children were more likely to report that their parents “are interested in science” or “want me to do well in math.”

### **Summary**

Theory predicts that students whose achievement is signaled to employers and universities by a curriculum-based external exit exam will have higher achievement in examined subjects. Our review of the evidence suggests that theory and the claims of advocates such examination systems are probably correct. Analyses of three very different international cross-section data sets found that students from countries with such systems outperform students from other countries at a comparable level of economic development in four different subjects--science, mathematics, reading and geography. Additionally, students living in Canadian provinces (and U.S. states) with such exams know more science and mathematics than students in other provinces. The variance of student achievement in countries and provinces with a CBEEES is no higher than in jurisdictions that lack such exams.

The paper then turned to an investigation of how the higher achievement comes about. CBEEES are not associated with higher teacher-pupil ratios nor greater spending on K-12 education. They are, however, associated with higher minimum standards for entry into the profession, higher teacher salaries, a greater likelihood of having teachers specialize in teaching one subject in middle school, a greater likelihood of hiring teachers who have majored in the subject they will teach and additional hours of instruction in examination subjects. Teacher satisfaction with their job appears to be lower, possibly because of the increased pressure for accountability that results from the existence of good signals of individual student achievement. Science labs are

better in CBEEES jurisdictions. The number of computers and library books per student are unaffected by CBEEES.

Fears that CBEEES have caused the quality of instruction to deteriorate appear to be unfounded. Students in CBEEES jurisdictions are less likely to report that memorization is the way to learn the subject and more likely to report that they did experiments in science class. Apparently, teachers subject to the subtle pressure of a provincial exam four years in the future adopt strategies that are conventionally viewed as "best practice," not strategies designed to maximize scores on multiple choice tests. Quizzes and tests are more common, but in other respects our indicators of pedagogy are no different in CBEEES jurisdictions. Students are also more likely to get tutoring assistance from teachers after school. They are not less likely to say they like the subject and they are more likely to agree with the statement that science is useful in every day life. Students also talked with their parents more about school work and reported their parents had more positive attitudes about the subject.

Some of the evidence on how student effort varies with exam systems appears to be inconsistent. In the analysis of Canadian data, students in CBEEES provinces did more homework and watched less TV. In the cross section of nations analysis, however, students in CBEEES nations did considerably less homework and spent a lot more time watching TV and hanging out with friends. Additional theoretical and empirical work is needed to resolve this discrepancy.

Important as CBEEES may be, they are not the only or even the most important determinant of achievement levels. General productivity levels and standards of living and an East Asian culture appear to have even larger effects. CBEEES are common in developing nations where achievement levels are often quite low [eg. Columbia and Iran]. Belgium, by contrast, has a top quality education system without having a CBEEES. More research on the system level determinants of average achievement levels is clearly in order.

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**Table 1: The Effect of Curriculum-Based External Exit Examinations on  
Science, Mathematics and Reading Achievement**

	Diploma Exam	Private Share	Private Share LT .11	Private Share GT .11	Education Spending % of GDP	Per Cap GDP 87--91	East Asia	Adj.R <sup>2</sup> RMSE
<b><i>TIMSS Science-1994</i></b>								
8 <sup>th</sup> Grade	42.2***					30.4***	11.1	.296
Mean	(3.20)					(2.78)	(.67)	36.0
Median	33.9**					37.3***	18.7	.313
13 yr olds	(2.50)					(3.59)	(1.09)	36.9
Median	30.1**				15.0*	31.5***	33.4	.381
13 yr olds	(2.30)				(1.94)	(3.01)	(1.89)	35.8
Median	32.3**	- 20.6				39.3***	23.7	.302
13 yr olds	(2.34)	(.69)				(3.61)	(1.27)	37.2
Median	27.4*		-304*	19.9		42.2***	33.5*	.342
13 yr olds	(2.00)		(1.85)	(.54)		(3.95)	(1.77)	36.1
<b><i>TIMSS Mathematics-1994</i></b>								
8 <sup>th</sup> Grade	37.3**					39.8***	57.8***	.400
Mean	(2.52)					(3.72)	(3.33)	38.0
Median	25.6*					48.5***	66.1***	.460
13 yr olds	(1.79)					(4.67)	(3.94)	36.7
Median	21.1				6.6	48.2***	75.0***	.494
13 yr olds	(1.45)				(.81)	(4.44)	(4.14)	37.0
Median	27.7*	18.1				46.8***	61.8***	.450
13 yr olds	(1.86)	(.60)				(4.33)	(3.36)	37.1
Median	19.6		-366**	71.3*		50.7***	74.8***	.520
13 yr olds	(1.37)		(2.30)	(2.00)		(4.96)	(4.16)	34.6
<b><i>IEA Reading-1990</i></b>								
Average --Age	24.5***					24.2***	-21.6*	.618
Adjusted	(3.06)					(3.46)	(2.04)	16.6
Average—	23.6**				2.1	23.7***	-18.6	.604
Age Adjusted	(2.79)				(.47)	(3.29)	(1.48)	16.9
Average --Age	22.0**	-24.7				27.9***	-11.8	.628
Adjusted	(2.67)	(1.46)				(3.73)	(.93)	16.4
Average-- Age	17.2**		-216**	- 4.1		29.7***	- 3.6	.634
Adjusted	(2.16)		(2.33)	(.22)		(4.28)	(.29)	15.1

**Source:** Grade level equivalents are approximately 26 for science and 24 for math and reading. The TIMSS analysis is based on 39-40 nations. The analysis of IEA reading data is based on 24-25 nations. T values are in parenthesis under the coefficients.

\*\*\* indicates the coefficient is significant at the 1 percent level on a two tail test

\*\* indicates the coefficient is significant at the 5 percent level on a two tail test

\* indicates the coefficient is significant at the 10 percent level on a two tail test

Table 2.--**How is Science and Mathematics Achievement Different in Nations with Curriculum-Based External Exit Examination Systems?**

	<i>Curriculum-based Exit Exam</i>	<i>Log GDP/ Pop 1987-91</i>	<i>East Asia</i>	<i>Achiev of 13 yr olds</i>	<i>Adj R<sup>2</sup> RMSE</i>	<i># of Obs</i>
<b>Variance of Achievement</b>						
TIMSS Science Standard Deviation (U.S. = 105.5)	1.5 (.37)	- 1.0 (.30)	- .2 (.04)	.077 (1.67)	.016 10.2	40
TIMSS Mathematics Standard Deviation (U.S. = 90)	2.8 (.96)	- 3.2 (1.25)	- 2.2 (.55)	.17*** (5.20)	.529 7.2	40
<b>International Assessment of Educational Progress--1991</b>						
Science-% Correct 13 yr olds (U.S. GLE =6)	4.3 (1.72)	1.7 (.61)	9.6** (2.81)		.436 4.0	15
Math--% Correct-13 yr olds (U.S. GLE = 8)	15.7*** (3.85)	3.7 (.25)	16.1** (2.81)		.641 6.0	15
Geography-% Correct Adjusted	2.9 (1.71)	1.5 (.78)	-3.3 (.89)		.127 3.4	21
Geography-% Correct Adjusted	3.5** (2.35)		-2.4 (.69)		.146 3.3	21

In TIMSS data grade level equivalents are approximately 26 for science and 24 for math. T values are in parenthesis under the coefficients.

\*\*\* indicates the coefficient is significant at the 1 percent level on a two tail test

\*\* indicates the coefficient is significant at the 5 percent level on a two tail test

\* indicates the coefficient is significant at the 10 percent level on a two tail test

**Table 3--Effects of Canadian Provincial Diploma Exams and School Governance  
on Student Achievement**

	Diploma Exam	Religious School Board	Independ- ent Religious School.	Independ- ent Non- Sectarian School	Elem, K-11, French	Books, Size, Sibs, Dif. Home Language	Comp uters, Calcul ators	Sch Inputs, Policies, T. Qualification & Hmwk	Adj R <sup>2</sup>
<b>Mathematics</b>									
1	.062*** (8.31)								.0476
2	.041*** (5.30)				X				.0914
3	.035*** (4.70)	-.041*** (5.77)	.149*** (6.66)	.091*** (3.68)	X				.1482
4	.051*** (7.58)	-.048*** (5.93)	.085*** (4.45)	.061*** (2.83)	X	X			.3291
5	.049*** (7.41)	-.058*** (7.23)	.085*** (4.51)	.059*** (2.81)	X	X	X		.3606
6.	.039*** (5.25)	-.046*** (5.26)	.066*** (3.44)	.024*** (1.13)	X	X	X	X	.3717
<b>Science</b>									
1	.035*** (6.09)								.0258
2	.026*** (4.57)				X				.1029
3	.025*** (4.40)	-.041*** (5.77)	.032* (1.95)	.044** (2.36)	X				.1308
4	.026*** (5.12)	-.029*** (5.88)	-.017 (1.18)	.012 (.73)	X	X			.3230
5	.027*** (5.19)	-.040*** (6.48)	-.020 (1.38)	.011 (.68)	X	X	X		.3316
6	.009 (1.52)	-.029*** (4.09)	-.052*** (3.40)	-.015 (.85)	X	X	X	X	.3592
<b>Principal Reports Problems with</b>									
Absen- teeism	.14*** (3.14)	.00 (.01)	-.42*** (3.31)	-.35** (2.44)	X	X			.1312
Discip- line	.017 (.40)	-.13** (2.55)	-.34*** (2.78)	-.16 (1.15)	X	X			.0795

The school problem indexes range from 0 = "no problem" to 3 for "serious". The means (standard deviations) were .78 (SD=.72) for discipline and .82 (SD=.77) for absenteeism. Column 8 variables are % of students who have a computer and % who have a calculator. The school policy variables include: hours of TV, homework, specialist teachers, teacher majored in subject taught, hours of science class, science labs, class size, preparation time, teacher experience & tracking.

**Table 4--How is Teacher and Student Behavior Different in Nations with Curriculum-Based External Exit Examination Systems?**

	<i>Curriculum-based Exit Exam</i>	<i>Log GDP/ pop-87-91</i>	<i>East Asia</i>	<i>Adj R<sup>2</sup> RMSE</i>	<i>#of Obs</i>
<b><u>Public Investment in Education</u></b>					
% GDP spent on Education	.24 (.81)	.55** (2.71)	-.86** (2.47)	.257 .76	41
Teacher Qualifications Index	1.53*** (3.80)	.70** (2.56)	-.18 (.39)	.304 1.04	42
% Salary Advantage of Lower Secondary Teachers/all workers	30.6* (2.03)	8.6 (.26)	10.0 (.40)	.107 (23.7)	17
% Salary Advantage of Upper Secondary Teachers/all workers	34.4 (1.64)	5.1 (.11)	12.7 (.36)	-.019 33.2	17
<b><u>Teacher Attitudes</u></b>					
Teacher Perception of Relative Status-1-100	- 6.1* (1.93)	-5.3** (2.19)	1.1 (.23)	.155 6.20	25
Society Appreciates my Work Science Teacher-% Yes	- 5.7 (.60)	6.9 (.96)	37.5** (2.51)	.117 19.1	27
Would Stay if teacher had opportunity to leave--% Yes	- 10.7* (1.97)	- 5.0 (1.20)	1.5 (.18)	.063 11.0	27
<b><u>Student Time Use</u></b>					
Homework in Other Subjects (hours per week)	- 1.68** (2.14)	-2.03*** (3.81)	1.17 (1.31)	.279 1.76	37
TV & Computer Games (hours per week)	2.47** (2.06)	1.1 (1.33)	-.90 (.65)	.054 2.75	38
Playing or Talking w Friends— (Hours per week)	3.12** (2.64)	2.14*** (2.68)	-5.39*** (3.97)	.354 2.70	38
Playing Sports (hours per week)	-.33 (.57)	.75* (1.92)	-3.65*** (5.55)	.509 1.31	38
Reading for Pleasure (hours per week)	.05 (.83)	-.20*** (4.45)	.06 (.81)	.366 .15	38

**Table 5--How is Science Teaching Different in Nations with Curriculum-Based External Exit Examination Systems?**

	<i>Curriculum-based Exit Exam</i>	<i>Log GDP/ pop-87-91</i>	<i>East Asia</i>	<i>Adj R<sup>2</sup> RMSE</i>	<i>#of Obs</i>
Memorization Necessary to do well in Science	-13.4** (2.31)	- 4.3 ( .98)	29.1*** (3.97)	.292 14.3	36
Hard Work Necessary to do well in Science	-3.5 (1.30)	-.7 ( .35)	6.3* (1.86)	.028 6.7	36
Natural Talent Necessary to do well in Science	11.2* (2.02)	-7.1* (1.71)	11.4 (1.63)	.250 (13.7)	36
Hrs Teachers Work outside of School Hours	.2 ( .30)	.07 ( .14)	11.8 (1.33)	-.017 1.73	36
Hours Meeting/Tutoring Students after school-Sci	.42*** (3.00)	-.10 ( .99)	.50*** (2.80)	.420 .35	36
Hours Preparing or Grading Science Tests	-.33 (1.30)	-.04 ( .20)	.02 ( .07)	-.034 6.3	36
Hours Reading & Grading Science Student Work	.22 ( .96)	.023 ( 1.37)	.64** (2.26)	.162 5.6	36
Freq. Of Student Reasoning Tasks in Science	-.04 ( .43)	-.27*** (4.08)	.03 ( .31)	.293 .209	34
Hrs of Sci. Homework Assigned/wk-by Teacher	-.09 ( .72)	-.18* (2.01)	-.06 ( .42)	.050 .285	34
Hrs Sci. Homework Done /wk—Student report	-.88* ( 1.93)	-2.1*** (6.23)	.39 ( .68)	.504 1.14	37
%Gen Science Students do Experiments-pretty often+	26.8** (2.50)	23.5*** (3.17)	6.5 ( .67)	.370 17.4	21
% Gen Science Students like Science	-.5 ( .08)	-11.6** (2.74)	-.6 ( .11)	.209 9.8	20

**Table 6--How is Mathematics Teaching Different in Nations with Curriculum-Based External Exit Examination Systems?**

	<i>Curriculum-based Exit Exam</i>	<i>Log GDP/ pop-87-91</i>	<i>East Asia</i>	<i>Adj R<sup>2</sup> RMSE</i>	<i>#of Obs</i>
Memorization Necessary to do well in Mathematics	- 4.9 ( .53)	- 3.6 ( .55)	16.0 (1.48)	-.016 21.7	37
Hard Work Necessary to do well in Mathematics	-2.0 ( .68)	- .8 ( .39)	3.7 (1.09)	-.045 6.9	37
Natural Talent Necessary to do well in Mathematics	8.3 (1.37)	- 9.2 (2.17)	11.1 (1.60)	.212 14.0	37
Hrs/wk Math Teachers Work outside of School Hours	1.1 (1.25)	.15 ( .24)	.21 ( .21)	-.033 2.0	36
Hrs/wk Meeting/Tutoring Students after school--Math	.34* (1.74)	-.13 ( .91)	.39* (1.73)	.164 .45	36
Hrs/wk Preparing or Grading Math Tests	-.23 ( .85)	-.11 ( .57)	-.23 ( .72)	-.034 6.3	36
Hrs/wk Reading & Grading Math Student Work	.31 ( .98)	.22 ( 1.00)	.42 (1.16)	.018 7.3	36
Freq. Of Student Reasoning Tasks in Math	- 12.6* (1.83)	-.13.8*** (2.88)	2.6 ( .33)	.161 15.7	34
Hrs/wk of Math Homework Assigned--by Teacher	-.07 ( .35)	-.45*** (3.07)	.05 ( .19)	.151 .484	38
Hrs/wk Math Homework Done—Student report	-1.16** ( 2.13)	-1.84*** (4.81)	.81 (1.29)	.381 1.26	37
Teacher teaches Whole Class	-6.0 (1.10)	-10.4** (2.71)	10.5 (10.5)	.159 (1.66)	38
% Quiz or Test used Pretty Often+	-20.2** (2.51)	- 2.2 ( .39)	6.5 ( .70)	.082 18.8	38
% Math Students like Mathematics	-1.3 ( .33)	-2.1 ( .75)	-.4 ( .08)	-.070 9.3	38

**Table 7--Effects of Canadian Diploma Exams on  
Administrator, Teacher and Parent Behavior**

	Dep Var Mean	School Std Dev	<u>Diploma Exam</u> Coef	AdjR <sup>2</sup> Tstat	
<b><u>School Administrator Behavior</u></b>					
Specialist Teachers do 8 <sup>th</sup> grade Math	.45	.50	.18	(6.9)	.280
Specialist Teachers do 8 <sup>th</sup> grade Science	.46	.50	.15	(5.6)	.279
8 <sup>th</sup> Grade Math Teachers Studied Math in Univ.	.64	.39	.19	(7.0)	.127
8 <sup>th</sup> grade Science Teachers Studied Science in Univ.	.69	.38	.19	(8.5)	.199
Math Class Hours/week	3.98	.88	.33	(5.9)	.124
Science Class Hours/week	1.95	.95	.28	(5.6)	.274
Computers per student	.051	.043	.001	(0.6)	.195
Average Class Size	24.8	6.1	-.15	(0.5)	.369
Teacher Prep Time	.31	.27	.001	(.01)	.222
Prop. Teachers with 10+ years of experience	.60	.24	-.025	(1.6)	.090
Prop. Teachers with under 3 years of experience	.16	.15	.012	(1.2)	.078
<b><u>Teacher Behavior</u></b>					
Total Homework (hours/week)	4.41	1.62	.66	(7.1)	.149
Emphasizes Whole Number Computation	1.68	.49	-.09	(2.9)	.035
Students do Science Experiments	1.52	.63	.28	(7.5)	.145
Teachers do Science Experiments	2.42	.47	.15	(5.4)	.111
Math Quiz/Test Index	1.62	.52	.10	(3.8)	.391
Science Quiz/Test Index	.89	.38	.10	(4.9)	.206
Students Work on Math Problems Alone	3.22	.41	.01	(.35)	.060
Solve Math Problems in Groups	1.46	.66	-.04	(1.0)	.137
<b><u>Home Behavior &amp; Attitudes</u></b>					
TV Hours/week	14.7	2.85	-.68	(4.2)	.255
Read for Fun Index	1.85	.28	.05	(2.8)	.115
Watch NOVA, Nature	.97	.38	.06	(2.7)	.091
Parents Talk about Math Class	.62	.17	.04	(3.4)	.046
Parents Talk about Science Class	.47	.17	.06	(5.2)	.056
Parents want me to do well in Math	3.54	.22	.05	(3.1)	.104
Parents are interested in Science	2.18	.34	.06	(2.6)	.071
Believe Science Useful in Everyday Life	2.46	.31	.06	(2.7)	.095
Math useful in solving everyday Problems	3.03	.31	.01	(0.5)	.084

Source: Analysis of IAEP data on 1338 Canadian schools. Control variables not shown included: logarithm of the mean number of books in the home, the mean number of siblings, the proportion of the school's students whose home language was different from the language of instruction, logarithm of the number of students per grade in the school and dummies for schools run by a locally elected Catholic (or Protestant) school board, independent secular and non-secular schools, schools with primary grades, schools that include all grades in one building, and French speaking school.

## APPENDIX A

### AN ECONOMIC THEORY OF THE EFFECTS OF PEER PRESSURE AND REWARDS FOR LEARNING ON SCHOOL PRIORITIES, STUDENT EFFORT AND ACHIEVEMENT

Much of the economic research on elementary and secondary education has employed a production function paradigm. Conventionally, test scores measuring academic achievement are the outputs, teachers are the labor input and students are goods in process.

This paper points in a different direction. Schools are viewed as worker managed organizations producing multiple outputs. In the classroom/school team production unit, students are as much workers as the teachers. Students are also consumers who choose which goals (outputs) to focus on and how much effort to put into each goal. The behavior of each of the system's actors (teachers, administrators, school board, students and parents) depends on the incentives facing them. The incentives, in turn, depend upon the cost and reliability of the information (signals) that are generated about the various outputs of the system.

In order to focus attention on the essence of the problem a very simple theoretical model containing just 6 equations is developed below. The six equations are: an achievement function, a rewards for achievement function, equations for the benefits and costs of student effort and for the benefits and costs of school inputs focused on academic achievement.

#### **The Achievement Function**

Learning is a change that takes place in a person. It occurs when an individual who is ready and able to learn, is offered an opportunity to learn and makes the effort to learn. All three elements are essential.

Learning readiness and ability--indexed by **A**--depends on prior learning, intelligence and family background. **A** is exogenous (ie. determined outside the model).

While, in principle, every literate individual with access to a library has the opportunity to learn, schools and teachers have, in practice, a great deal of influence on what youngsters learn and at what pace. Educators determine what courses are required, which electives are offered, the topics covered, teaching methods, homework and paper assignments and classroom expectations. In our model opportunity to learn is operationalized as school quality or **QX**. School quality is the product of two variables, one exogenous, the other endogenous (ie. determined within the model). **X** is a composite index of the teacher behaviors, school inputs and policies fostering academic achievement that are controlled by educators and their political supervisors. **X** is the teacher and/or school



administrator's choice variable.  $Q$  is an exogenous efficiency index measuring how effective  $X$ , the chosen school inputs and policies, are at improving student achievement.  $Q$  can also be viewed as an index of the teaching technology available to the educators.

While facilitating learning is the primary purpose of American schools, other goals compete for school resources and administrative attention. Among the other goals are child care, improved health and nutrition, discouraging drug use, student self esteem, community service, opportunities for physical exercise, equalizing opportunities and/or outcomes, achieving racial balance in school populations and community entertainment (eg. band and interscholastic sports). Consequently,  $X$  should not be confused with per pupil expenditure. The model is designed to explain the priority that schools give to academic learning as a goal, not school spending.

The part of the learning equation controlled by the student is effort ( $E$ ). Students choose which courses to take and how much effort to devote to each course. Classroom observational studies have found that the time engaged in learning is considerably less than the time available for learning and that time on task varies a great deal across students and across classrooms (Frederick 1977, Frederick, Walberg and Rasher 1979). Time devoted to homework also varies a great deal. In 1990, 33 percent of 17 year olds reported doing two or more hours of homework each night, while another 15 percent reported not being assigned homework or not doing the homework assigned (NCES 1993 p. 352).

Just as important as the time devoted to learning is the intensity of the student's engagement in the process. Sizer (1984) concluded, "No more important finding has emerged from the inquiries of our study than that the American high school student, as student, is all too often docile, compliant, and without initiative" (p. 54).

Student-teacher ratios of 17 to 1 imply that, in the aggregate, students spend nearly 17 times as many hours learning as teachers spend teaching. Student time and engagement is, therefore, probably the most important input in the educational process.

All of these factors are summarized in the simple equation:

$$(1) \text{ Human Capital at the end of secondary school} = L = AE^{\alpha}(QX)^{\beta} \quad \alpha + \beta < 1$$

where  $E$  = Student Effort--an index of the time and psychic energy that K-12 pupils devote to learning per year of school attendance.

$X$  = A composite index of inputs and policies that foster academic achievement. Within countries this index is positively correlated with per pupil spending but the relationship may weak. In most countries academic achievement is not the sole goal of schools and serving other objectives conflicts with teaching academic subjects. In addition schools are not assumed to be operating on the production frontier.

$Q$  = Efficiency Factor for  $X$ , the School Inputs Index.

$\alpha$  = elasticity of human capital ( $L$ ) with respect to Effort

$\beta$  = elasticity of human capital ( $L$ ) with respect to School Academic Quality ( $QX$ )

I have assumed the human capital production function is Cobb-Douglas with  $\alpha + \beta < 1$ . This gives the model a number of realistic features.

- (a) School quality and student effort interact positively. An improvement in teacher quality enhances the effect of greater student effort and vice versa.
- (b) A 20 percent increase in both effort ( $E$ ) and school quality ( $QX$ ) increases human capital ( $L$ ) by less than 20 percent.

### The Extrinsic Rewards for Achievement Function

(2) Present Discounted Value of Pecuniary and other

$$\text{External Rewards for Achievement} = \Pi = wL + \theta(L - L_m) + \sigma A$$

where  $w$  = the impact of absolute levels of achievement (human capital) at the end of secondary school on the present discounted value of lifetime earnings and other extrinsic rewards for learning. It includes the effects of secondary school learning that operate through admission to preferred colleges, completing college, successful pursuit of lucrative but difficult majors such as engineering, entry into and completion of graduate programs. It also includes the benefits that parents derive from the economic success of their children and the honor and prestige given to those who are seen as high achievers. Curriculum based external examinations increase  $w$ , the payoff to absolute achievement, and tend to reduce  $\theta$ , the payoff to one's relative position (rank) in the secondary school's graduating class, and  $\sigma$  the payoff to IQ and family background.

$L - L_m$  = Student achievement relative to the school mean ( $L_m$ ). Rank in class and grades awarded on a curve are examples of signals of achievement that describe the student's achievement relative to others in the school.

$\theta$  = the impact of achievement relative to the school mean on the present discounted value of lifetime earnings (includes impacts on admission to preferred colleges and the benefits that parents derive from the economic success of their children).

$\sigma$  = the impact of  $A$  (ie. early IQ, early achievement and family background) on the present discounted value of lifetime earnings.  $\sigma$  would be large and  $w$  and  $\theta$  small if access to college depended solely on family background and IQ test scores obtained prior to entering secondary school. The SAT is not a pure IQ test, but relative to curriculum based exams it is at the aptitude end of the spectrum. Consequently, substituting curriculum based exams for the SAT in university admissions decisions would lower  $\sigma$  and raise  $w$ . Since  $A$  is assumed exogenous, changes in  $\sigma$  do not effect student incentives to study or community incentives to invest in schools.

It is important to note that the specification implies that studying by one student imposes costs on other students. Greater achievement for person  $i$  increases school mean achievement,  $L_m$ , and lowers everyone else's position relative to the mean (eg. rank in class). In fact the loss that others experience when person  $i$  tries harder is exactly equal to  $\theta(L - L_m)$ , the gain person  $i$  experiences from raising her achievement relative to the school mean.

If, for example, there are 200 students in the graduating class, a one unit increase in  $L_i$  for person  $i$  raises  $L_m$  by .005. This lowers the benefits that each of the 199 other students get from the second term of equation 2 by  $.005 \cdot \theta$ .

### Choosing Learning Effort

The student is not just another input in an educational process controlled and directed by others. Rather, students are more appropriately viewed as entrepreneurs trying to grow and develop in an environment shaped by a great variety of forces: history, parents, teachers, peers, employers, government, society, and their own abilities. Students generally, and secondary school students especially, choose what to study and how hard to work at learning it. That is the issue being addressed in this model: how hard to study; not whether to stay in school one more year.

When making these choices students compare expected benefits to expected costs. The benefits are both extrinsic ( $\Pi$ ) and intrinsic ( $j$ )--the joy of learning for its own sake and the honor and respect that parents and teachers give for achievement.

### **Student and Parent Benefits of Effort Equation**

$$(3) \text{ Student and Parent Benefits of Effort} = B = (w + \theta + j)[AE^\alpha(QX)^B]$$

where  $j$  = the present discounted value of the intrinsic non-pecuniary benefits, **joy**, of learning received by the student and her parents. Note that these benefits are assumed to occur regardless of whether the learning is signaled to others or honored publicly.

### **Student and Parent Costs of Effort Equation**

The costs are time, psychic energy, money for tuition and books, loss of control over one's in-class time and, frequently, peer pressure against learning.

$$(4) \text{ Costs of Student Effort} = C = C_0 E^\mu + c_1 \theta L$$

where  $C_0 E^\mu$  = the costs that arise from giving up other more pleasurable activities when time and energy are devoted to learning.

$\mu$  = the elasticity of this cost with respect to effort.  $\mu > 1$  because the marginal cost of effort rise as effort increases.

$c_1 \theta L$  = the costs of effort that result from the fear that one's classmates will think you are a *"nerd...teachers pet...or acting white."* When  $c_1 = 1$ , the anti *nerd* pressure against academic effort exactly offsets the losses that trying harder imposes on others  $\theta(L - L_m)$  because greater achievement for person  $i$  increases school mean achievement,  $L_m$ , and lowers everyone else's position relative to the mean (eg. rank in class). If  $c_1 > 1$ , anti-nerd peer pressure imposes larger costs on the studious than they impose on their classmates.

### Community Benefits of Giving Academics High Priority Equation

Communities similarly base their choices about spending and priorities on a comparison of benefits and costs. Community decisions about school spending and the priority attached to learning are motivated by benefits that students get from general improvements in their academic achievement,  $w_m$  and  $j_m$ .

(5) Community/Social Benefits of

$$\text{Giving Academic Achievement Top Priority} = B_s = P(w_m + j_m)[A^m E_m^\alpha (QX)^B]$$

where  $P$  = a parameter characterizing the political power of parents and other beneficiaries of high academic standards in the governance of schools relative to the power of those whose objectives lie elsewhere {eg voters who place highest priority on the nonacademic functions of schools or whose main concern is keeping taxes down}.

$w_m$  = the average impact of absolute levels of achievement (human capital) on the extrinsic benefits of learning (includes impacts on admission to preferred colleges and the benefits that parents derive from the economic success of their children and the externalities that other citizens receive from a student's learning).

$j_m$  = the average present discounted value of the non-pecuniary benefits, **joy**, of learning received by students and parents and non-pecuniary externalities received by others.

Note how  $\theta$ , the benefit of improving one's ranking relative to school mean achievement, does not appear in the equation describing community benefits of greater learning.

### Cost of School Inputs Equation

$$(6) \text{ Cost of school inputs \& policies devoted to academic achievement} = D = D_0 X^\gamma$$

where  $\gamma$  = The elasticity of the costs of school inputs with respect to increases in  $X$ .  $\gamma \geq 1$ .

### Determining Student Effort

To study the determinants of student effort, we define a net benefits of study effort equation,  $B - C$ , by subtracting eq.4 from eq.3, and then obtain the maximum of the function by differentiating it with respect to  $E$ , effort assuming  $X$  fixed..

$$(7) \max B - C = (w + \theta + j)[A E^\alpha (QX)^B] - [C_0 E^\mu + c_1 \theta L]$$

The derivative of (6) with respect to  $E$  for the average student is:

$$8) \frac{\partial(B-C)}{\partial E} = \alpha(w+\theta+j)[AE^{\alpha-1}(QX)^{\beta}] - \mu C_0 E^{\mu-1} - \alpha c_1 \theta [AE^{\alpha-1}(QX)^{\beta}] = 0$$

The third term is combined with the first.

$$9) \frac{\partial(B-C)}{\partial E} = \alpha[w+j+(1-c_1)\theta][AE^{\alpha-1}(QX)^{\beta}] - \mu C_0 E^{\mu-1} = 0$$

$$10) E^{\mu-1}/E^{\alpha-1} = E^{\mu-\alpha} = \frac{\alpha[w+j+(1-c_1)\theta][A(QX)^{\beta}]}{\mu C_0}$$

$$11) E = \{ [\alpha/\eta C_0][w+j+(1-c_1)\theta][A(QX)^{\beta}] \}^{1/(\mu-\alpha)}$$

$$12) \ln E = \left( \frac{1}{\mu - \alpha} \right) \left[ \ln \frac{\alpha}{\mu} - \ln C_0 + \ln(w + j + (1 - c_1)\theta) + \ln A + \beta \ln Q + \beta \ln X \right]$$

### Determining Community Investment in School Quality

We determine the community's investment in school quality by subtracting the costs of that investment, eq. 6, from its benefits, eq. 5, and then determining the maximum for the function by differentiating with respect to  $X$  while assuming  $E$  fixed.

$$13) B_S - D = P(w_m + j_m)[AE_m^{\alpha}(QX)^{\beta}] - D_0 X^{\gamma}$$

$$14) \frac{\partial(B_S - D)}{\partial X} = \beta P(w_m + j_m)[AE_m^{\alpha} Q^{\beta} X^{\beta-1}] - \gamma D_0 X^{\gamma-1} = 0$$

$$15) X = \{ [\beta/\gamma D_0] P(w_m + j_m)[AE_m^{\alpha} Q^{\beta}] \}^{1/(\gamma-\beta)}$$

$$16) \ln X = \left( \frac{1}{\gamma - \beta} \right) \left[ \ln \frac{\beta}{\gamma} - \ln D_0 + \ln(w_m + j_m) + \ln P + \ln A + \beta \ln Q + \alpha \ln E_m \right]$$

The problem with equation (12) and (16) is that they both contain two endogenous variables. To obtain an equation for  $\ln E$  in terms of exogenous variables only, we substitute 16 into 12 and solve for  $\ln E$ . An equation for  $\ln X$  is obtained similarly.

17)

$$\ln E = \frac{\gamma}{\Delta} [\ln A + \beta \ln Q] + \frac{\gamma - \beta}{\Delta} \left[ \ln \frac{\alpha}{\mu} - \ln C_0 + \ln(w + j + (1 - c_1)\theta) \right] + \frac{\beta}{\Delta} \left[ \ln \frac{\beta}{\gamma} - \ln D_0 + \ln(w_m + j_m) + \ln P \right]$$

18)

$$\ln X = \frac{\mu}{\Delta} [\ln A + \beta \ln Q] + \frac{\alpha}{\Delta} \left[ \ln \frac{\alpha}{\mu} - \ln C_0 + \ln(w + j + (1 - c_1)\theta) \right] + \frac{\mu - \alpha}{\Delta} \left[ \ln \frac{\beta}{\gamma} - \ln D_0 + \ln(w_m + j_m) + \ln P \right]$$

Where  $\Delta = (\mu - \alpha)(\gamma - \beta) - \alpha\beta > 0$

From these two equations we can calculate the elasticity of the response of **E**, **X** and **L** with respect to each of the exogenous variables:

Exogenous. VARIABLE(S)	Student Effort	School Inputs	Learning
19) $C_0$	$\eta_{EC_0} = -\left(\frac{\gamma - \beta}{\Delta}\right)$	$\eta_{XC_0} = -\left(\frac{\alpha}{\Delta}\right)$	$\eta_{LC_0} = -\alpha\left(\frac{\gamma - \beta}{\Delta}\right) - \beta\frac{\alpha}{\Delta} = \frac{-\gamma\alpha}{\Delta}$
20) $D_0$	$\eta_{ED_0} = -\left(\frac{\beta}{\Delta}\right)$	$\eta_{XD_0} = -\left(\frac{\mu - \alpha}{\Delta}\right)$	$\eta_{LD_0} = -\alpha\frac{\beta}{\Delta} - \beta\frac{\mu - \alpha}{\Delta} = \frac{-\mu\beta}{\Delta}$
21) $Q$	$\eta_{EQ} = \frac{\beta\gamma}{\Delta}$	$\eta_{XQ} = \frac{\beta\mu}{\Delta}$	$\eta_{LQ} = \beta\left(1 + \frac{\gamma\alpha + \mu\beta}{\Delta}\right)$
22) $P$	$\eta_{EP} = \left(\frac{\beta}{\Delta}\right)$	$\eta_{XP} = \left(\frac{\mu - \alpha}{\Delta}\right)$	$\eta_{LP} = \alpha\frac{\beta}{\Delta} + \beta\frac{\mu - \alpha}{\Delta} = \frac{\mu\beta}{\Delta}$
23) $A$	$\eta_{EA} = \frac{\gamma}{\Delta}$	$\eta_{XA} = \frac{\mu}{\Delta}$	$\eta_{LA} = 1 + \left(\frac{\gamma\alpha + \mu\beta}{\Delta}\right)$

Equal proportionate rises in both private and social payoffs to learning

24) Payoff	$\eta_{EA} = \frac{\gamma}{\Delta}$	$\eta_{XA} = \frac{\mu}{\Delta}$	$\eta_{LA} = \left(\frac{\gamma\alpha + \mu\beta}{\Delta}\right)$
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Equal proportionate rises in both private costs of effort and the public costs of school inputs

25) $C_0 + D_0$	$\eta_{ECD} = \frac{-\gamma}{\Delta}$	$\eta_{XCD} = \frac{-\mu}{\Delta}$	$\eta_{LCD} = -\left(\frac{\gamma\alpha + \mu\beta}{\Delta}\right)$
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Note how the effects of increases in the costs of effort and school inputs are equal and opposite to the effects of a proportionate increase in real payoffs to learning. A proportionate increase in costs and benefits would leave student effort levels, school input levels and learning unchanged. In equations 26, 27 and 28, I bring together the effects of all of the exogenous variables that might be expected to differ between rich and poor nations.

Real income per capita's relationship with Student Effort (E) and the School Input Index (X):

$$26) \quad \eta_{EY} = \frac{(\kappa + \beta\lambda + \phi_P - \eta_{CoY})\gamma + \beta\eta_{CoY} - \alpha\eta_{DoY}}{\Delta}$$

$$(27) \quad \eta_{XY} = \frac{(\kappa + \beta\lambda + \phi_S - \eta_{DoY})\mu - \beta\eta_{CoY} + \alpha\eta_{DoY}}{\Delta}$$

Real Income per capita's Relationship with Student Achievement (L):

28)

$$\eta_{LY} = \kappa + \beta\lambda + \alpha \frac{(\kappa + \beta\lambda + \phi_P - \eta_{CoY})\gamma + \beta\eta_{CoY} - \alpha\eta_{DoY}}{\Delta} + \beta \frac{(\kappa + \beta\lambda + \phi_S - \eta_{DoY})\mu - \beta\eta_{CoY} + \alpha\eta_{DoY}}{\Delta}$$

Where  $\kappa$  = the ratio of the growth of A, the index of learning readiness and aptitude, to productivity growth in the economy as a whole. A tends to increase with per capita GDP because learning is facilitated by improvements in health and nutrition and exposure to a rich cultural environment.

$\lambda$  = the ratio of the growth of Q, the productivity of schooling inputs directed towards academic achievement, to productivity growth in the economy as a whole.  $\lambda < 1$ .

$\phi_P$  = the elasticity of the private benefits of learning with respect to per capita GDP (estimated in a cross section of nations).  $\phi_P$  is likely to be below 1 because in rich countries competition for places in higher education is less intense, wage premiums for skills are lower, marginal tax rates are higher and welfare programs more generous.

$\phi_S$  = the elasticity of the social benefits of learning with respect to per capita GDP (estimated in a cross section of nations).  $\phi_S$  would be below 1 if social rates of return to learning are lower for richer countries because wage premiums for skill are smaller or because the externalities of learning become less important as skills become less scarce.

$\eta_{CoY}$  = the elasticity of the cost of student effort with respect to per capita GDP.

$\eta_{DoY}$  = the elasticity of the cost of school inputs with respect to per capita GDP.

The Relationship between Economic Development and Student Learning: An examination of eq. 28 reveals that students in richer countries will tend to have higher achievement than students in poorer countries when (a) learning readiness, A, is higher, (b) the productivity of schooling inputs, Q, is greater [ $\lambda > 0$  and close to 1] and (c) benefits of investing more money and effort in learning rise more rapidly than costs as incomes rise [the third and fourth terms of the equation are positive]. These are also the reasons conventionally given for why people in rich countries stay longer in school. Since A and Q are higher in richer countries, achievement can be pretty confidently predicted to be higher as well.

The Relationship between Economic Development and Student Effort and School Inputs devoted to Academics: One can not be sure, however, that E and X will be higher in richer countries. Scitovsky pointed

out many decades ago that wage premiums for skill are much higher in less developed nations than in developed nations. This suggests that costs of learning rise more rapidly than the pecuniary benefits of learning as countries develop [eg. that  $\phi_s < \eta_{DoY}$  and  $\phi_P < \eta_{CoY}$ ].  $\eta_{DoY}$  is likely to be less than one because the relative wage of teachers is likely to fall as the economy grows richer and purchased schooling inputs such as computers, books, buildings and electricity do not become more expensive as the economy grows. Thus unless the social benefits of learning fall precipitously with development, eq 27 is likely to be positive so  $X$  will rise with GDP per capita.

$\eta_{CoY}$ , by contrast, is likely to be greater than 1 because higher standards of living result in workers (and probably students as well) choosing to work fewer hours per week. This implies that a doubling of per capita GDP is generally associated with an even larger increase in wage rates and a still larger increase in the opportunity cost of time at a given number of hours worked per week or per year. Since private rates of return to schooling fall as GDP per capita rises, it is possible that eq 26 is negative and that, conditional on school attendance, student effort ( $E$ ) will fall as GDP per capita rises.

It is important to note that the benefit-cost calculus for deciding how many years to stay in school is different from the calculation of how much effort to put in school given that one is attending. Compulsory schooling laws can force students to attend but they cannot force students to study. Tuition can be lowered or stipends covering costs of living can be offered to induce students to attend school but they have no direct effect on marginal decisions about how hard to study. There are also differences with respect to benefits. In many countries, learning as distinct from years in school is poorly signaled and consequently poorly rewarded immediately after completing school. Years of completed schooling, by contrast, is always well signaled and is, consequently, well rewarded. Policies of social promotion allow students to obtain this signal without putting in much effort. If students are promoted to the next grade or given a diploma only when they achieve above some standard, a higher level of effort will be required to obtain the signal.

### **The Effects of Curriculum-Based External Exit Exams on Effort and Learning**

What does this model tell us will happen to student effort, the school input index and achievement when curriculum based external exams are introduced. Curriculum based exams cause an increase in  $w$ , the extrinsic reward for absolute achievement.

The model predicts that a rise in  $w$ , the pecuniary benefits of increases in the absolute level of human capital ( $L$ ) at the end of high school, from whatever cause--technical change, shifts in college admissions policies or establishing a system of curriculum based examinations--will have positive effects on student effort, school inputs devoted to raising academic achievement and student learning. The impact of economic rewards is largest when



non-pecuniary motives are less important than pecuniary motives (ie.  $\mathbf{j}$  is considerably smaller than  $\mathbf{w}$ ), when anti-nerd peer pressure is strong (eg.  $\mathbf{c}_1 > 1$ ), when the elasticities of learning with respect to effort ( $\alpha$ ) and school inputs ( $\beta$ ) are substantial, and when the marginal cost curves for  $\mathbf{E}$  and  $\mathbf{X}$  are flat (eg.  $\mu$  and  $\gamma$  are close to 1).

Curriculum based external exit exams (CBEEEs) increase  $\mathbf{w}$ , the pecuniary rewards for absolute levels of academic achievement, in two ways. First, they improve the signals of high school achievement available to colleges and employers and thus cause these institutions to give greater weight to high school achievement when they make admissions and hiring decisions. In the process their decisions become less sensitive to other factors such as aptitude tests like the SAT, family connections, racial and religious stereotypes, recommendations of a previous employers and the chemistry of twenty minute job interviews. Total rewards for achievement will rise,  $\frac{\partial(\mathbf{w} + \mathbf{j} + (1 - \mathbf{c}_1)\theta)}{\partial(\text{CBEEE})} > 0..$

Second, curriculum based external examinations can be expected to shift attention and rewards from measures of relative achievement such as rank in class and teacher grades to measures of absolute achievement (eg. grades on the external exam). In mathematical terms,  $(\partial \mathbf{w} / \partial \text{CBEEE}) > 0$  probably implies a  $(\partial \theta / \partial \text{CBEEE}) < 0$ . The decline in  $\theta$  does not influence school priority decisions because  $\theta$  does not appear in the equations describing the benefits and costs of  $\mathbf{X}$ , school inputs. The likely decline in rewards for relative achievement has an ambiguous effect on student effort. The equations for these impacts are:

$$29) \quad \frac{\partial \ln E}{\partial \theta} = \frac{\gamma}{\Delta} \left( \frac{1 - \mathbf{c}_1}{\mathbf{w} + \mathbf{j} + (1 - \mathbf{c}_1)\theta} \right) \quad 30) \quad \frac{\partial \ln E}{\partial \mathbf{w}} = \frac{\gamma}{\Delta} \left( \frac{1}{\mathbf{w} + \mathbf{j} + (1 - \mathbf{c}_1)\theta} \right)$$

Since  $\mathbf{c}_1$  is positive, equation 29 is always less positive than equation 30. Thus, in the unlikely event that a curriculum based exam decreased  $\theta$  by the same amount it increased  $\mathbf{w}$ , student effort would increase because peer pressure against studying would decrease. The positive  $\mathbf{c}_1$  reflects the fact that anti-nerd peer pressure against studying is caused in part by institutions that reward relative rather than absolute achievement. When one student's success comes at the expense of other students, students as a group pressure their classmates to put out less effort. If peer pressure is so strong that it outweighs the pecuniary benefits that students expect from being ranked at the top of the class,  $\mathbf{c}_1 > 1$  and a reduction in these rewards ( $\theta$ ) will increase student effort.

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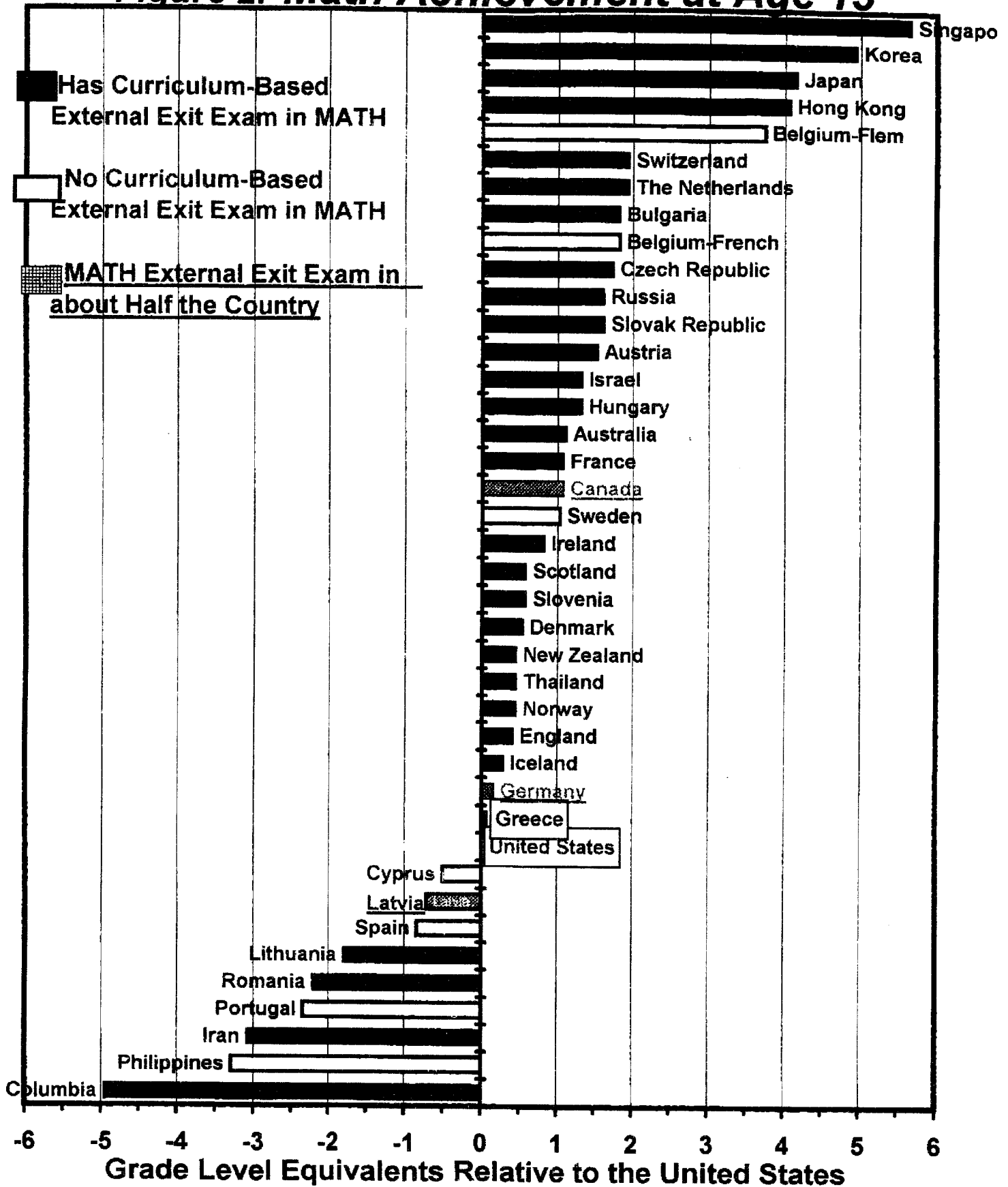
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# Figure 2. Math Achievement at Age 13



**Figure 3: Science Achievement at Age 13**

