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Human Capital Development and Education

by

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Skills and Knowledge for Canada's Future: Seven Perspectives
Towards an Integrated Approach to Human Capital Development

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Executive Summary

Human capital theory holds that the well-being of a society is a function not only of the traditional stocks of financial capital, labour and natural resources but also of the knowledge and skills of individuals. This theory predicts that increased knowledge and skill will yield improved economic outcomes for both individuals and societies, especially in modern societies, where it is widely held that knowledge and skill convey a greater economic and social premium than in the past.

Education is a key element of human capital theory because it is viewed as the primary means of developing knowledge and skill. Most research around the human capital development and education is based on Mincer's *human capital earnings function,* which predicts that earnings are a function of educational attainment and work experience. There is evidence that human capital development is a strong influence on educational policy, with statements to this effect being found in the goal and mission statements of many educational agencies and jurisdictions.

The issue of the economic return to education is the subject of another paper in this series. This paper focuses instead on the conditions required to achieve desired educational outcomes. This is based on an "education production function" which treats educational resource allocation and use as independent variables and educational achievement as the outcome.

The classic Mincer model addresses educational "attainment," typically measured by years of education completed or by credentials. However, in a thrust more consistent with the theory itself, some research has also been concerned with the actual knowledge and skill acquired through exposure to education. Some evidence exists to indicate that educational performance, in the form of grades achieved or literacy indicators, have an effect on economic returns independent of attainment. However, an argument can be made that the greatest impact of achievement lies not directly on economic returns but on access to higher levels of education. In particular, grades achieved in school are the key determinant of admission to universities and colleges where, arguably, the greatest individual economic benefits can be acquired. Investigating the determinants of school performance is thus key to understanding the relationship of education to human capital development.

Much of the research on the education production function has occurred in the United States. The main issue there has been the value of resource allocations as a vehicle for improving both overall performance and equality of educational outcomes. Studies have typically focused on longitudinal trends in state-level expenditures, the effects of disproportionate expenditures on the disadvantaged and proxies for resources, such as class sizes and teacher qualifications.

This work has generated substantial controversy with Hanushek and some others using the data to argue consistently that resource allocations have little impact (though resource use may) and others, such as Greenwald, Hedges and Laine and Grissimer and colleagues at the RAND Corporation using much the same data to make the opposite argument. Some recent experimental studies of class size have advanced the case for positive effects of investing resources in smaller classes. However, critics continue to hold that this is not a cost-effective

approach because of the large resource outlays required to bring about class size reductions large enough to have an impact. It has also been argued that the key to class size effects is whether teachers do anything different in smaller than in larger classes.

Recent large scale achievement studies shed some light on the issue because they have been able to measure a large number of proxies for resources. In these studies, class size has typically had effects in the opposite direction from expectations or has had non-linear effects. The latter has typically been attributed to the practice of placing lower performing students in smaller classes, with this not yielding the desired effect. There are some indications that quality of school resources, pre-school attendance and teacher specialization have positive effects on achievement. However, none of these are as strong as student socioeconomic background as predictors of achievement. All of these studies suffer from the limitation of short-term measurement of the resource related variables.

The results of this line of research suggest that resource use is more important than resource allocation. This is the basis for a different line of research intended get inside the "black box" of what actually happens in schools and classrooms. A large amount of research based on the mediating effects of school and classroom processes on outcomes was conducted in the 1970s and 1980s with results indicating that particular teaching strategies and school leadership styles are contributors to higher achievement. However, this work seems to have tapered off in recent years in favor of large scale surveys.

Despite its profound impact on educational policy thinking at the highest levels, the evidence on the impact of educational resource expenditures on educational outcomes remains, at best, inconclusive. This paper concludes with a series of recommendations for more focused research on the definition and measurement of outcomes, developing and testing more comprehensive models of the factors contributing to achievement, selective use of randomized clinical trials to test prospective high cost policy initiatives, obtaining more long-term measures of resource impacts and, finally, a more systematic research agenda related to the mediating effects of school and classroom processes.

1. Introduction

1.1 Overview of Human Capital Theory

Human capital theory holds that the well-being of a society is a function not only of the traditional stocks of financial capital, labour and natural resources but also of the knowledge and skills of individuals. This "human capital" can be used like any other asset to generate outcomes of value to individuals and society. In particular, the theory predicts that increased knowledge and skill will yield improved economic outcomes for both individuals and societies. This idea has attained increased prominence in the past couple of decades because of the widely held view that we are in a "knowledge economy," in which knowledge and skill convey a greater premium than in the past.

Sweetland (1996) traces the origins of human capital theory to the work of Adam Smith in the 18th century and John Stuart Mill in the 19th. However, the modern formulation of human capital as part the overall economic production function is generally traced to mid 20th century Nobel Prize winning works by Schulz and Becker. Both of these works have had fairly recent updates (Schultz, 1993; Becker, 1993). Earlier works by Freidman and Kuznets (1945; cited in Sweetland, 1995) and Solow; 1957; cited in Sweetland, 1995) were also, major contributors to development of the theory. The primary concern of these economists was why economic development has advanced faster than the growth of the stocks of traditional capital and labour and, more specifically, how to explain the large residual component in traditional economic production functions. Human capital theory locates this explanation in knowledge and skill and particularly in education and work experience as the primary sources of these attributes.

1.2 Human Capital Theory and Education

Education is a key element of human capital theory because it is viewed as the primary means of developing knowledge and skill and because level of education is a way of quantifying the quality of labour. Mincer (1974) is generally credited with developing the core model designed to explain differences in individual income as a function of level of education and work experience. Mincer's *human capital earnings function* has income as the dependent variable and years of education the main independent variable[1]. Work experience is also typically included in the model as a proxy for unobserved sources of acquisition of knowledge and skill.

Much subsequent human capital research, especially that conducted by economists, can be seen mainly as attempts to refine and extend the Mincer model. A large number of specific issues have been investigated. Of particular interest is the effect of gains in income through education relative to the opportunity costs in lost work time in attaining higher education levels. There is also the question of whether education is of value because it contributes to knowledge and skill or whether education is merely a proxy for underlying ability. This view leads to the competing concept that education is not a cause of economic outcomes but is more of a screening device used by employers to select those most likely to have the desired abilities. For example, it may be argued that those most likely to persist in schooling are those who possess other attributes

[1] This is an oversimplification of the Mincer model, just as that model is an oversimplification of the real world. Since we do not intend to pursue the issue of economic outcomes in detail here, it is not considered necessary to elaborate this model in either conceptual or mathematical terms.

most valuable to employers. The requirement for specific credentials for access to many high level occupations may be seen as an extreme example of the screening idea. This is illustrated by studies of *sheepskin effects,* or the additive effects of possessing a credential over that of years of education (Ferrer and Riddell, 2002).

A broader issue is the extent to which public or private educational expenditures represent investment rather than consumption. The private return on educational expenditures has been widely investigated and is now rarely questioned. The return to society is less well established and more difficult to model because of the myriad of possible causes (and effects if we go beyond economic outcomes). This issue is at the heart of the debate over the proportions of educational costs that should be borne by individuals versus governments. Larger individual benefits lead to an argument for individuals bearing a larger proportion of the cost. Larger societal outcomes present an argument for greater public investment. This issue is also linked to policies in which education is considered a means of reducing poverty and of moving individuals from reliance on income support to self-reliance.

1.3 Focus of this Paper

Almost all of the research on the place of education in human capital development has been concerned with the economic returns to education. Most of this research has taken the form of attempts to estimate the individual wage premiums associated with higher levels of education and, more recently to separate the causal effects of education from those of other confounding factors. Societal returns have generally been inferred from individual returns, although some comparative studies have focused more specifically on country level returns. Because another paper in this series is specifically concerned with economic returns, this area of research receives only brief treatment here. In effect, the first two of the above questions are left to the economics paper and we focus on the remaining questions. More specifically, this paper focuses on human capital theory as a driving force for recent research and policy-making in education. Thus, rather than using the conventional model of education as input and economic return as outcome, we examine education policies and practices, and particularly resource allocations as inputs with educational attainment and achievement as outcomes.

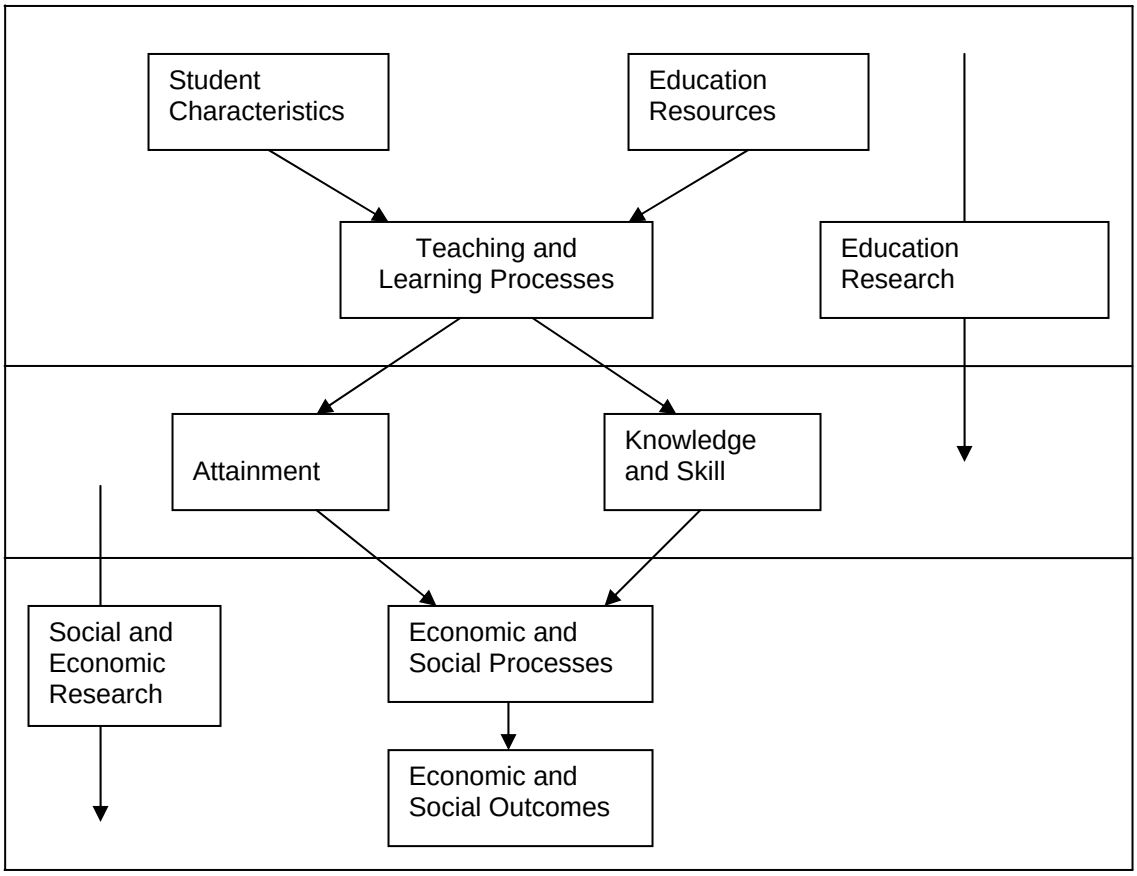
Aside from the contribution of education to the overall economic production function, human capital theory also underlies studies of the impact of specific forms of investment in education and of differing uses of the resources available to education. Under this approach, educational attainment becomes the proximate dependent variable and educational resource allocations and uses the independents. The underlying issue here is not the economic return to education but the cost-effectiveness of uses of educational resources. Ideally, an argument can be made that the preferred educational structures and strategies are those which yield the greatest attainment or achievement for the least cost. For example, the desired balance of expenditures at different levels of education (early childhood, elementary/ secondary, post-secondary, lifelong learning, skills training) can be related to the relative returns to these levels. Unfortunately, this kind of cost-benefit analysis is not easy to carry out and is not necessarily widely supported in a political environment which considers any form of educational expenditure to be desirable and where, until fairly recently, educational expenditures have been viewed as outcome rather than input.

While comprehensive cost-benefits analyses continue to elude educational researchers, there have been many studies of the allocation and use of educational resources. Many recent large

scale cross-national and, in Canada, cross-provincial comparative studies are concerned with the relative performance of various jurisdictions, as measured by a wide variety of indicators. More specific studies have examined such factors as school size, class size, overall expenditures, teachers' salaries and the like as contributors to improved performance, all under the implicit assumption that higher educational performance is a societal good and that the goal is to determine how best to use the resources available to education

Figure 1 gives a simplified schematic model designed to capture the distinctions made here. For economists and other social researchers, the main focus is on the bottom two layers of the model. For educational researchers the main interest is on teaching and learning processes. The usual end points for the educational researcher, namely attainment and achievement, are the starting points for the economist.

Figure 1: Conceptual Model of Education and Human Capital Development



It is important to note that this model is intended to capture the thrust of research on human capital development as it relates to formal education. Other sources of knowledge and skill such as work experience itself and informal and non-formal learning, are not included here as these have not been the subject of much research. Similarly, the concept of lifelong learning, which has become a prominent feature of many educational policy and mission statements, is not strictly a part of the model, again because there is much advocacy and sentiment but little research around this idea.

This paper does not address the large body of research on the relationships among student characteristics, teaching and learning processes and outcomes. While this represents a core area of educational research in its own right, the theoretical basis for most of the research in this area is found mainly in the psychology of learning, and not in human capital theory. An argument will be made later in this paper for the need for convergence of resource-outcome and process-outcome research. However a review of the latter is beyond the scope of the paper.

2. Human Capital Development and Educational Policy

Whatever the level of empirical support for human capital theory, it is not difficult to document the extent to which this theory forms the basis for educational policy. Virtually all major policy statements in education begin with reference to the knowledge society and the importance of education for individual, state or provincial prosperity. Indeed, even though a case can be made that education has other important goals, it is difficult to imagine that the current high level of both individual and public financial commitment to education could be sustained without an abiding faith in the economic value of education.

On an international level the economic significance of education is a focus of research by the Organization for Economic Cooperation and Development (OECD). A few statements from recent OECD publications illustrate the extent to which one of the world's foremost economic policy organizations has taken the importance of education to economic development as given.

> *Educational attainment is becoming increasingly important, relative to other factors, in shaping young people's life chances. Changing economic and social conditions – information and communication technologies, the globalisation of economic activity, greater personal responsibility and autonomy in all aspects of life – have given knowledge and skills an increasingly central role in the economic success of individuals and nations. In addition to the growing economic importance of human capital, the social returns to learning, in the form of enhanced personal well-being and greater social cohesion, are also significant (OECD, 2005).*

> *Education is an investment that can help foster economic growth, contribute to personal social development and reduce social inequality. Like any investment, it involves both costs and returns. Some of the returns are monetary, and directly related to the labour market, while others are personal, social, cultural or more broadly economic. Some returns accrue to the individual while others benefit society in general, for example, in the form of a more literate and productive population. (OECD, 1996).*

The periodic OECD *Education at a Glance* (e.g. OECD, 2005*)* reports have become standard references on education inputs and outcomes. Comparative statistics on educational inputs, processes and outcomes are taken seriously as measures of educational quality. The underlying assumption is that all of this does have something to do with economic productivity. Indeed, such indicators as post-secondary expenditures or participation rates are sometimes taken as outcomes in themselves, on the apparent assumption that these are proxies for economic prosperity.

Within Canada, although education is under provincial jurisdiction, a large federal government presence can be found in areas in which education touches on labour market development. Traditionally, this has been confined to the post-secondary level, where skills development has been a major element in successive federal economic development strategies. However, there is increased evidence of a federal presence in early childhood, K-12, literacy and adult basic

education, albeit in ways intended not to raise too many jurisdictional red flags.[2] It is not difficult to identify an explicit human capital development focus in federal agencies concerned with education and labour market development.

To illustrate the point, the federal government's 2004 budget included provision for a new "workplace skills strategy." The description of this strategy opens with the following statement:

> *At present, the Canadian economy is being transformed by global, technological, and demographic shifts, each of which has serious skills implications. In the emerging knowledge-based and globalized economy, a nation's primary competitive advantage will lie in the strategic use of human resources. Improving Canada's competitive position means ensuring that Canadian workers have the skills, knowledge and supportive environment needed to excel, to contribute to innovation, and to remain flexible and resilient in the face of ever-changing work demands.*
>
> *Human capital development is a shared responsibility of both public and private sectors, with the Government of Canada helping to play a leadership and partnership role (http://www.hrsdc.gc.ca/en/ws/initiatives/wsi/WSI_proposal_overview.shtml)*

In a similar vein, the mission statement of the National Literacy Secretariat begins with the following statement:

> *Forty-two percent of Canadians aged 16-65 do not have the literacy skills required for full participation in the knowledge economy. The **National Literacy Secretariat (NLS)** works to promote literacy as an essential component of a learning society and to make Canada's social, economic and political life more accessible to people with weak literacy skills. (http://www.hrsdc.gc.ca/en/hip/lld/nls/About/aboutus.shtml)*

Similar statements can be found in the documentation for dozens of other federal government programs providing support to students, workers, schools and researchers.

The situation is no different at a provincial level. For example, New Brunswick has recently developed a "prosperity plan" which places education at the forefront of a range of strategies to increase economic activity in that province. This plan states:

> New Brunswick will have a quality education system that fosters a culture of lifelong learning for citizens from the earliest moment, aspires to excellence and achievement at all times, and ensures graduates have the knowledge and are well prepared to successfully participate in today's knowledge economy (Government of New Brunswick, 2002)

A similar sentiment can be found in the most recent business plan of the Alberta Ministry of Advanced Education.

[2] It is notable that federal agencies assiduously avoid using the word "education" in their titles or programs, and that most such programs involve funding or research but not the operation of programs.

Alberta's vision
A vibrant and prosperous province where Albertans enjoy a superior quality of life and are confident about the future for themselves and their children.

Mission of the Ministry of Advanced Education
In support of Alberta's vision, Advanced Education's mission is for Alberta to be a learning society where all Albertans have access to the opportunity to develop the learning, work and life skills they need to achieve their aspirations and maximize their potential to the benefit of themselves and Alberta.
(http://www.advancededucation.gov.ab.ca/department/businessplan/bp2005-08.pdf)

A similar thrust can be found in ministerial statements, curriculum documents, accountability reports and other sources, to the point where there is little doubt that human capital development is one of the primary drivers of educational policy. Indeed, it may be argued that much of the increase in efforts at accountability and outcome assessment in education is driven by the need for the system to be seen as productive in achieving the outcomes that are key to human capital development.

Of course, this perspective is not without its critics. Aside from researchers who continue to cast doubt on the empirical validity of human capital theory, there are many who believe that education is about more than providing a ready supply of skilled workers, and that the system has responded too much to government and corporate labour market demands. Critics of the accountability movement are particularly vocal in decrying what they believe is a "corporate agenda" now pervading educational policy and the resulting homogenization of the system (Puk, 1999; Wien and Dudley-Marling, 1998). Some have even called on teachers to actively resist this movement (Hyslop-Msrgison, 2000)

3. Research on Human Capital Development and Education

3.1 Economic Returns to Attainment, Credentials and Performance

The classic human capital function takes the form of a regression equation with wages as the outcome and years of education (attainment) and work experience as predictors. However, some fairly recent studies have attempted to include knowledge and skill directly into the model. Since this research has not received the same amount of attention as the research on levels of education, and since some Canadian studies can be found, this area is examined briefly here.

Krahn and Lowe (1998) used data from the International Adult Literacy Study (IALS) to examine the match between literacy skills possessed by Canadian adults and their use in the workplace. The study showed that almost three-fourths of Canadian workers are employed in a job appropriate to their literacy skills. Of the one-fourth of workers exhibiting a mismatch, almost four times more have higher literacy levels than are demanded by their jobs (literacy surplus), than are in jobs requiring higher skills than possessed by the worker (literacy deficit). Literacy surplus was found to be more common among women and younger workers. The study also provided some evidence that literacy skills may be lost if not used.

In a follow-up study, Krahn and Bolby (1999) used data from the National Graduates Surveys of 1990 and 1995 to examine the match between education and job skills using a traditional fit between educational credentials and jobs and a generic skills approach based on reported use of skills derived from the Employability Skills Profile (Conference Board of Canada, 2000). Results showed that graduates from professional programs, as well as those having advanced degrees experienced a better education-job skills match on both the "credential fit" and "generic skills" measures. On the other hand, humanities and social sciences graduates experienced a better match of generic skills than of credentials to their jobs. Further analysis revealed that leadership and teamwork skills are less likely to be developed in post-secondary programs than cognitive, communications and new-technology skills. Finally, the results indicated that a significant minority of graduates do not have the opportunity to use all of their employment related skills in their jobs.

In two further papers based on IALS data, Osberg (2000) and Green and Riddell (2001) investigated the hypothesis that literacy can have an impact on earnings beyond that which is associated with educational credentials. Osberg's concern was mainly with measurement issues, particularly with various ways of scaling the literacy scores. Nevertheless, he found that literacy had a significant impact on earnings no matter how the scores were scaled, accounting for about 30 percent of the economic return from education. The same result was found by Green and Riddell. These authors also found that educational attainment has a larger impact than work experience on earnings. The study also provided some support for the view that literacy skills may play a role in how well immigrants adjust to the labour market.

Charette and Meng, (1998) used Canadian data from the earlier Statistics Canada *Survey of Literacy Skills Used in Daily Activities* to examine the returns on literacy. These authors found that including literacy and numeracy measures in the income equation increases the return to education for males but decreases it for females. Similar results were found by Osberg (2000)

and Dalton (2004). These results suggest that performance is more important for males and years of education more important for females.

A review by Walters (2004) presents the competing arguments of credentialism versus human capital theory. In particular, Walters examined the work of Collins and others who argue that a "credential society" has emerged in which education is valued less for its ability to create knowledge and skill than for its ability to sort individuals in convenient ways to create a hierarchy in job selection and advancement. Walters also cites the work of Livingstone and others as providing evidence that the premium on education has been declining and that the system is now producing many overqualified workers. While not inconsistent with the evidence on positive individual returns to education, the credentialist perspective suggests the possibility that higher education is a zero sum game or worse at the societal level.

Walters used results from the 1997 National Graduates study to investigate the education-job match and, in particular, whether those with higher levels of education reported a better fit to their work than those at lower levels. After controlling for a number of background factors, graduates of professional programs had the highest probabilities of a close match, followed by Master's and Ph.D. graduates. Despite the conventional wisdom which holds that trades and college graduates obtain education that is more directly job-related than typical university undergraduate programs, only small differences in job match were found among these three groups. These results were reinforced by an analysis of fields of study, which showed much higher probabilities of close match for those in specific fields of study, such as education, health and engineering than for humanities, fine arts or social science graduates. This latter result was obviously related to requirements for specific credentials for entry to many jobs in these fields.

The relationship between academic achievement (as opposed to attainment or credential) and economic outcomes gained attention when Hernstein (1971) argued that labour market outcomes were predictable from test scores. The premium on school-based achievement seems to have been an explicit component in only a few studies of economic impact. Jencks (1979) examined this relationship using data from seven countries, and estimated that a one standard deviation increase in test scores accounts for an increase of between 3 percent and 27 percent in earnings.[3] Hanushek (2004) and Altonji and Blank (1999) reached the same conclusions, after controlling for other factors such as work experience, labour market conditions and individual characteristics.

In the United Kingdom, Dolton and Makepeace (1990), using a survey of university graduates, concluded that post graduation earnings were higher for those with first or second class degrees. Blackburn and Neumark (1993) found increased wages to be associated with higher levels of academic ability. A further U.K. study by Naylor, Smith and McKnight (2000) also found significant increases in earnings with degree class. Specifically, a 5.5 percent premium was associated with a first class degree, a 2.6 percent premium for a second class degree and a 2.6 percent deficit for a third class degree. These same authors, in a 2002 study, found that the premium on a first class degree increased between 1985 and 1998 to 9.4 percent for males and 11.2 percent for females. Hernstein and Murray (1994) argued that the rising return to education

[3] This section draws heavily on a literature review conducted by Stephanie Dalton as part of her M.Ed. thesis (Dalton, 2004). The author is indebted to Stephanie Dalton, for stimulating his interest in the effects of performance on economic outcomes and for permission to draw from her work.

is attributable to a rising return to ability. Grogger and Eide (1995) and Murname, Willett and Levy (1995) also found positive returns to performance.

Dalton (2004) examined the question of whether there is a premium on the grades achieved in university, controlling for the effects of credentials, individual characteristics and labour market effects. Dalton was able to match the results from about 1,800 respondents to a 2002 follow-up survey of university graduates with the academic records of these same students. She was also able to extend the data set by incorporating labour market information on a variety of occupations from the 2003 edition of the *Job Futures* report published by Human Resources Development Canada.

Dalton found that, on average, there is a return on grades. This return is small relative to the premiums on education level and credential but they persist even when these factors are controlled. The size of the return is specific to specific groups and contexts; in particular, inclusion of separate grades for Mathematics and English in the model results in a positive return for mathematics and a negative return for English. The return to academic major is positive in a bivariate model but becomes negative in a model with controls for individual and labour market characteristics and credential. The return to English in high unemployment rate occupations is negative for females and positive for males. The return to grades is stable across credential groups but varies across low and high unemployment groups.

The most obvious area in which a premium on grades can be found is not directly in the economic return to grades but in the use of grades as the means of access to higher levels of education. However, this seems not to have been considered in the research. This is most apparent in the transition between secondary and post-secondary education. Since post-secondary education is not (yet) universal, high school grades are the main selection device for entry to post-secondary institutions, and especially to universities.[4] The well established premium on post-secondary education clearly depends on the student achieving at a sufficient level, first to gain access to a post-secondary institution and second to continue to achieve at a level sufficient to graduate. In addition, undergraduate grades are the major determinant of entry to the "high level" professional schools and to graduate studies. This, of course, means that the premium on grades is likely to mirror that on credentials. As far as we can tell, there have been no studies of the effects of grades within credential areas. We do not know, for example, if engineers or business graduates with high grades do better than those with the same credentials but lower grades.

3.2 The Return to Educational Resource Inputs

While the existence of an individual premium on education is well established, it does not follow that this has a positive impact on society as a whole. Nevertheless, the dominant belief is clearly that the aggregate of individual benefits is a societal benefit. More directly, the belief is that education has a causal effect on overall economic activity, presumably through increasing the supply of those workers most in demand, creating a climate of entrepreneurship or more

[4] High school grades are less extensively used in the United States than in Canada and other countries because few U.S. jurisdictions have state-wide high school graduation examinations and because broader aptitude tests such as the SAT are in wide use in the United States. However, this simply alters the measure, not the principle.

generally increasing the productivity of the work force. As pointed out earlier, this belief is a strong driving force for public expenditures on education.

On the surface, the most obvious way to study the returns to society is by applying the human capital earnings function to cross-national or cross-system (systems could be schools, districts or states/provinces) data. Alternatively, it is possible to examine time series data, and particularly the effects of deliberate shifts in educational policy designed to yield higher education levels for larger numbers of people. Again, this area of research belongs more properly to the economics paper. For now, we follow the policy thrust and assume that there is a societal benefit and that some level of expenditure (or investment) of public resources is necessary to achieve this benefit. This leads to the main contribution of educational research to the human capital development issue, that of the impact of different levels of resources and of different ways of using these resources. Most such research is based, at least implicitly, on a variation of the human capital function which we may call the *education production function.* In this model, the dependent variable is educational attainment or achievement and the independent variables are educational expenditures or proxies for expenditures, such as class sizes, teacher qualifications or program interventions of various kinds.

3.3 United States Studies

Most of the research on the education production function comes from the United States. This work is generally thought of as having its origins in the Coleman study of educational equality (Colemen, et al., 1966). That study has been widely interpreted as indicating that most of the difference in educational achievement is due to home and family circumstances, exacerbated in the United States by race, and that the effects of schooling (and by implication of educational expenditures) are minimal. Jencks, et al. (1972) used a reanalysis of the Coleman data to argue that individual differences are about equally hereditary and environmental, with a large residual, but that, among environmental factors, increasing equality in school resources would contribute little to increasing equality in economic outcomes. This early work stimulated a debate which continues to this day. Educators quite naturally challenge the proposition that schools make no difference and governments continue to devote substantial resources to education on the assumption that they do.

A common thrust of such research involves the use of national time series data on resource inputs and outcomes. Resources are typically expressed as per-pupil expenditures or as cost-intensive resource uses such as class sizes, teacher salaries or teacher qualifications. Typically, these resource measures are correlated with either NAEP results or results on the Scholastic Aptitude Test (SAT), although use of the latter measure has been criticized because of differential participation rates over time and across states.

Perhaps the most influential work of this nature is that of Eric Hanushek. In a series of individual studies and syntheses extending over 20 years Hanushek (1981, 1986, 1989, 1991, 1997, 1999) has consistently concluded that the research evidence is insufficient to support any strong or consistent relationship between resource inputs and student achievement. Although Hanushek's work remains influential, it is perhaps a measure of the controversial nature of this work, and the existence of countervailing arguments, that there is little indication of policy makers using this work to keep resources constant or to justify decreases.

A strong challenge to Hanushek's conclusions has been presented by Greenwald, Hedges and Laine (1996). These authors were critical of Hanushek for using simple vote counting (counting the number of statistically significant effects) in his synthesis work. Using the techniques of meta-analysis to combine effects across many studies, these authors found positive effects for a variety of resource variables including per-pupil expenditures, pupil/teacher ratio, school size (higher achievement in smaller schools) and teacher ability, education and experience. Estimates were made of the effect on achievement of a change of $500 per student. These ranged from .04 of a standard deviation for pupil/teacher ratio to .22 for teacher education. Despite their general conclusion, however, these authors pointed out that there are large variations in effects across studies, and especially across different methods (e.g. cross-sectional versus longitudinal).

In a response to Greenwald, et al., Hanushek (1996) pointed out that meta-analysis can point only to the possibility that some resource effects are positive, a point consistent with his argument that what matters is not resources but how they are used. Hanushek was also critical of the selection method used by Greenwald, et al., arguing that this method excludes too many useful results. For example, Hanushek (1996) presented data showing large increases in these resource inputs from the 1960s to the 1990s but only small increases in achievement on the National Assessment of Educational Progress (NAEP), arguing that this presents a prima facie case for minimal resource effects. Hanushek also examined the common arguments that much of the increased funding has gone into reducing racial disparities and other special programs for the disadvantage and that students are coming to school less prepared than in earlier years. Hanushek concluded that, on balance, student input characteristics have improved rather than deteriorated and that changes in student inputs cannot account for the lack of achievement gains.

A comprehensive literature review by Grissmer, et al. (2000) examined the issue of disproportionate spending on the disadvantaged, arguing that this should result in larger increases in achievement for the targeted groups. This, indeed, has been the case, with the largest gains in NAEP scores being found for black, Hispanic and lower achieving white students. This has been interpreted as evidence that targeted use of resources yields the desired payoff. However, this seems to have had little impact on overall average performance.

Grissmer, et al. (2000) also examined the results of more recent reviews and, while concluding that there is now general support for positive resource effects, variation across study methods, levels of aggregation and analytical approaches continue to plague the field. There seems to be no consensus on methods of analysis, other than that measurement at lower levels of aggregation (e.g. student or school) yields better results than those at higher levels (e.g., state or country) and that some of the inconsistencies can only be resolved by using experimental or quasi-experimental studies.

The Tennessee STAR study of class size has been widely cited as one of the few significant attempts at experimentation using a resource variable.[5] In that experiment, the State of Tennessee randomly assigned about 6000 kindergarten students in 79 schools to class sizes of approximately 15 and 23. These class sizes were maintained through Grade 3. Additional students entering the experimental schools were also randomly assigned, giving a total of about

[5] An early Canadian experiment on class size (Shapson, et al., 1980) was widely cited in earlier reviews of class size but seems now to have been superseded by the high profile of the Tennessee experiment.

12,000 students having some exposure to the experiment. Class sizes then reverted to normal (larger and variable) class sizes up to Grade 8.

The results of this experiment showed statistically significant positive achievement effects from smaller classes at all grades and for all subjects up to Grade 8 (Finn and Achilles, 1999). The long- term effects seem confined to students who had been in the small classes for all four years (Nye, et al., 1999). Short-term effects were greater for black and other disadvantaged students. Although questions have been raised about departures from the experimental design that inevitably occur in a large scale implementation (Hanushek, 1999), these have been addressed and not found to have been significant sources of bias.

A more recent similar study has been conducted in Wisconsin (Molnar et al., 1999). This study used a slightly different, quasi-experimental, design and focused more explicitly on disadvantaged students. The one year results were similar to those for the Tennessee experiment but with smaller effect sizes. As far as we can determine, no longer-term results have yet been reported.

A further thrust is found in studies of differences across states in resource allocation and use. Grissmer et al. (2000) justified the use of comparative state-level data on the grounds that states are the primary policy-making bodies, that there is substantial variation among states in resources allocated and that states have implemented a large variety of reforms over the past couple of decades, many of which have been explicitly directed at improving achievement. The existence of state level scores on the NAEP assessment also provides a valid and comparable dependent variable.[6] In effect, state differences may be viewed as a "natural experiment" on the effects of resource variation. Grissmer and his colleagues at the RAND Corporation set out to examine state-level effects, controlling for other factors known to influence achievement. In particular, it was argued that developing state-level family background indicators from census and other data provided a more accurate picture than using student self-reported data for NAEP questionnaires. The Grissmer study was also unique in attempting to estimate the cost-effectiveness of various resource utilizations.

The results indicated, as expected, that family characteristics account for most of the variance across scores within states. However there were also significant state-specific effects for students with similar family backgrounds. Some of these can be explained by characteristics of state educational systems, and particularly by variations in per-pupil expenditures and how these expenditures are allocated. In particular, higher levels of participation in public pre-kindergarten programs, lower pupil-teacher ratio in lower grades, higher reported adequacy of teacher resources, and lower levels of teacher turnover showed positive effects on achievement. Higher teacher salaries, higher teacher education levels and increased teacher experience beyond three years did not show significant effects. Wide variations in the cost-effectiveness of expenditures were also found, depending on grade level, programs and the SES levels of students. The most cost-efficient use of resources were providing K-8 teachers with more teaching resources, expanding pre-kindergarten programs in low-SES states and implementing low student-teacher ratios in lower grades in lower-SES states.

[6] Because the publication of state-level NAEP results has been voluntary, not all states are available for all analyses.

Although the results for the impact of reform were considered preliminary, there were several indications that reform initiatives have yielded some payoff. In particular, a case study of the two states – Texas and North Carolina – which had the highest achievement gains, revealed that similar reforms, involving increased accountability, standards and assessments, had occurred in both states to a greater degree than elsewhere. In general, these results suggested that the way in which resources are allocated is more important than simply increasing resources and that resources are more effective when targeted at the most disadvantaged students. More specifically the authors suggested that targeting resources to improved teacher working conditions, including smaller class sizes, would be more effective than using the same resources to increase teacher salaries.

In his more recent work, Hanushek has continued to challenge other studies on resource effects. In a critique of the Tennessee STAR experiment, Hanushek (1999) questioned some of the design features of STAR, suggesting that these bias the results upward. More important, he argues that the results are predicated on unrealistically large reductions in class size, beyond what could be implemented on a system-wide scale. Indeed, the STAR results are consistent with the earliest well-known review of class size (Glass and Smith, 1979), which concluded that little benefit is derived until class size is reduced to around 15 students. Hanushek has also argued that large scale survey results, which tend to show either no class size effects or effects in favour of larger classes, cannot be ignored because, despite their correlational nature, they are more representative of the real world and more generalizable across systems and countries than any experiments that have been done. Finally, Hanushek argued that class size reduction is one of the costliest of educational reforms and that the observed effects are clearly not sufficient to justify the costs involved in implementing general class size reductions.

3.4 International Achievement Studies

Hanushek and Luque (2003) used results from international large scale assessments to present a broader argument about the effects of resources. A general summary of results from six international mathematics and science assessments from 1970 to 1995 is presented as indicating no systematic pattern, at the country level, between resources and test results. The coefficients associated with per-student expenditures, student-teacher ratio and the ratio of total expenditures on education to GDP all show these resource indicators as having negative impact. Hanushek and Luque argue that organizational features of education systems are more likely than resources to influence outcomes.

Building on these results, Hanushek and Luque used data from the Third International Mathematics and Science Study (TIMSS). This study involved achievement measures of 9, 13 and 17-year-olds in more than 40 countries, along with extensive student, teacher and school questionnaires. In this case, the country level results yielded slightly greater evidence of resource effects than earlier studies. However, school level analyses within countries yielded few consistent effects for class size, teacher education and teacher specialization. In particular, Hanushek and Luque argue that there is no clear support for the hypothesis that resources have a greater effect in developing than in developed countries. School effects explain substantial variance in achievement in the absence of controls for family factors but the explanatory power of school variables is substantially attenuated once family factors are controlled. Hanushek and Luque acknowledge that the results depend on whether family factors are considered precursors to schooling or the other way around. Nevertheless, although the order of entry of variables into

a regression equation is mathematically arbitrary, it is logically difficult to think of a model which places school variables ahead of family variables in a causal sequence since children are exposed to family influences long before they enter school.

Finally, it is useful to examine results of the Programme for International Student Assessment (PISA), a new periodic assessment being conducted by the Organization for Economic Cooperation and Development (OECD). The PISA assessment was administered in 32 countries in 2000 with reading as the core subject and in 41 countries in 2003 with mathematics as the core subject. Like the IEA studies, PISA uses a sophisticated design which is capable of producing reasonably accurate country-level statistics on a variety of student and school characteristics, as well as achievement. While the PISA data has not yet been fully exploited to examine the education production function, this data base offers considerable potential for such analysis.

The school resource factors available from PISA 2000 were student-teacher ratio, school size and levels of teacher qualifications. School size has not typically been examined but an argument can be made that larger schools should offer some economies of scale and hence should be more efficient. These variables were available at the school level for all participating countries. Variations across countries and within countries could thus be examined.

While the PISA report (OECD, 2001) noted that student-teacher ratio is not the same as class size, this is perhaps a better resource indicator than class size since it is not confounded with issues of teacher deployment. On average, a 10 point increase (or .10 standard deviation on the PISA scale) in reading performance was associated with having 3.3 fewer students per teacher. However, this relationship was non-linear, with both the smallest and the largest being associated with lower performance than the mid range ratios. The results at the low end were attributed to the practice of having smaller ratios in schools with low achieving students. Those at the high end were consistent with the conventional view that larger ratios are detrimental to achievement.

On average, a 10 point gain in achievement was associated with having just over 200 more students in a school. However, this relationship was also non-linear, with little gain being seen for schools over 1,000 students. Finally, a 10 point gain was associated with 27 percent more teachers in the school having a tertiary level qualification with a major in the subject being taught.

Within countries, most of the effects were statistically non-significant, with substantial differences in their values across countries. An argument can thus be made that the significance of the overall effects is more a consequence of the large sample size (of schools) or, alternatively, that the small sample of schools within countries leads to instability in the results.

The PISA report also examined the relative effects of school and family factors on achievement. As in most other studies, resource and other school level effects were found to be attenuated in the presence of family factors. One effect that seems to be unique to PISA is student use of school resources. This was found to have a positive influence on performance but was also related to family background. It may be argued from this that students from higher SES families may make better use of school resources, thereby adding to the advantage already available. On the other hand, using a broader range of school indicators, it was also found that schools can help mitigate the adverse effects of low SES. Indeed, a few countries, including Canada, seem to

have been able to combine high levels of performance with relatively low impacts of SES on performance.

PISA 2003 (OECD, 2004), which focused on mathematics, took a slightly different approach to resources. While retaining student-teacher ratio and school size, an overall index of school resources was developed by combining responses to several questionnaire variables. A more sophisticated multi-level modeling approach was also taken. For the mathematics scale, school size and the index of quality of school resources were statistically significant overall but student-teacher ratio was not. Within countries, very few of the effects were significant. Again, the report noted the possibility that the absence of an effect for student-teacher ratio may be related to the placement of weaker students in smaller classes. This possibility was also observed for other resource-related variables such as tutoring and out of class lessons in mathematics. Both of these were negatively correlated with mathematics performance but it was not possible to separate the effects of these activities on "like" students from the broader likelihood that weaker students are more likely to be exposed to these activities.

3.5 Canadian Evidence

No Canadian studies were found which directly addressed the effects of resources on outcomes. However, it is possible to identify some effects from the international studies and the Student Achievement Indicators Program (SAIP). The most recent edition of the report *Education Indicators in Canada* (Statistics Canada, 2003) also contains some comparative information.

Looking first at PISA, Tables 1 and 2 give the effect sizes for Canada and the overall effect for all OECD countries for the resource variables discussed earlier, plus some others included in the tables but not addressed in detail in the report.

Table 1: PISA 2000: Canadian and OECD Resource Effects for Reading

Resource Indicator	Unit	Change in reading score per unit on resource variable	
		Canada	OECD
Student-teacher ratio	20-25 compared to less than 20	**22.86**	-.73
Student-teacher ratio	25-30 compared to less than 20	-7.70	-10.03
Student-teacher ratio	More than 30 compared to less than 20	**-40.71**	**-22.48**
Percent of computers available to 15-year-olds	One percent increase	**-0.51**	**-0.69**
Teachers with tertiary qualification in subject of test	One percent increase	**.39**	**.30**
Quality of school infrastructure	1 standard deviation increase	**2.41**	2.26
Student use of school resources	1 standard deviation increase	**8.44**	**16.18**
Source: OECD, 2001, Table 8.5a. statistical significance of OECD effects inferred from reported standard errors			

Table 2: PISA 2003: Canadian and OECD Resource Effects for Mathematics

Resource Indicator	Unit	Change in reading score per unit on resource variable	
		Canada	OECD
School size	Increase of 100 students	1.83	**4.7**
Student-teacher ratio	One student increase	**3.57**	0.7
Pre-school attendance	One or more years at a pre-kindergarten program	**13.74**	**8.0**
Quality of school resources	One standard deviation increase	**5.92**	**2.4**
Teacher shortage	One standard deviation greater shortage	**-5.59**	**-3.7**
Source: OECD, 2004, Tables 5.20 and 5.21			

The 2000 effects are based on models controlling for SES. The 2003 effects are based on multilevel models, controlling for a wider range of variables.

The non-linear effects of student-teacher ratio in reading are more apparent for Canada than for OECD as a whole. Being in schools with mid-range student-teacher ratios is clearly advantageous. Again, on the low end, the result is likely related to the assignment of low achieving students to smaller classes. The results at the high end seem to support an argument for reducing the size of the largest classes, rather than a general reduction. The student-teacher data are not broken down by categories for mathematics but the overall relationship shows a performance advantage for higher student-teacher ratios.

Both quality of school infrastructure (reading) and quality of instructional resources (mathematics) show positive effects on performance. This is also true for student use of resources. What is less clear is whether high quality resources or increased use are a consequence of higher expenditures. On the other hand, student access to computers, a relatively expensive resource that schools have been struggling to provide, shows a negative effect for reading.

Teacher specialization was positively related to reading scores. However, this index is not available for mathematics. Instead, an index of teacher shortage was used. This also showed an effect in the expected direction, with greater reported shortage being associated with lower achievement.

The School Achievement Indicators Program (SAIP) is a Pan-Canadian assessment operated by the Council of Ministers of Education since the early 1990s. Samples of 13-year-old and 16-year-old students in all jurisdictions (including separate English and French samples in some jurisdictions) have been assessed in Mathematics, Reading and Writing and Science on a cyclic basis. The last three assessments, mathematics in 2001, writing in 2002 and science in 2003 have included comprehensive student, teacher and school questionnaires, allowing some analysis of the kinds of relationships of interest here. The public reports have included comparative data on a large number of variables but correlational results on only a few. Although some ongoing research is attempting to develop more comprehensive models of achievement from the SAIP data, results of these projects are not yet widely available.

Only a small number of correlations in the public reports touch on resource variables. These are summarized in Table 3. The effects noted are those showing statistically significant effects across most jurisdictions. Although these results are based on bivariate correlations, with no control for student characteristics, the pattern is generally consistent with what has been found in other studies. The result for parents helping to raise funds seems unique to this study. The actual impact of such fund-raising efforts on the overall school budget and on outcomes is unknown but warrants study in light of the controversial nature of school fund-raising activities. In particular the prevalent view seems to be that schools must engage in fund raising to make up for shortfalls from government sources. If so, there is a further link to socioeconomic status, with schools in more affluent areas likely being capable of raising larger amounts in this way.

Table 3: SAIP Correlations Between Resource Variables and Achievement

Mathematics 2001	
Positive	Negative
School size	Percentage of students with learning problems
Mathematics class size (larger classes)	
Writing 2002	
School size	Percentage of students with learning problems
Language arts class size (larger classes)	Shortage of specialized teachers
Parents help raise funds	Shortage or inadequacy of instructional materials, space, infrastructure
Science 2004 No consistent patterns for any variables	
Sources: CMEC, 2003a, 2003b, 2005	

The *Education Indicators in Canada* Report (Statistics Canada, 2003) gives total, per-capita and per-student expenditures on education, and trends in these expenditures, for Canada and the provinces. In principle, it should be possible to use these in conjunction with SAIP performance to develop relationships similar to the state level patterns found in American studies. In practice, this does not yield significant effects for several reasons. To begin with, variations in expenditures across provinces are not as large as those found across states in the U.S., nor are the variations in achievement. Also, the small number of jurisdictions would require very high correlations to reach statistical significance. Finally, the results depend very strongly on whether or not the territories are included since these jurisdictions have both exceptionally high expenditures and exceptionally low achievement.

Nevertheless, it is interesting to note that the two provinces, Alberta and Quebec, which have consistently outperformed others on SAIP and PISA, have tended to have expenditures slightly below the Canadian average, while the two with the highest expenditures per student, Ontario and Manitoba, have tended to show mid-level performance. The Atlantic provinces have had expenditures considerably below the Canadian average and have tended to have among the lowest achievement levels. While this may be suggestive of a non-linear relationship between expenditures and performance, the data are inadequate to infer a clear pattern.

3.6 The Mediating Effects of Teaching and Learning Processes

The conceptual model indicates that resources can be expected to exert effects on outcomes only indirectly, through their effects on teaching and learning processes. This is consistent with the

position taken by Hanushek and others that resource use, not resource magnitude, is the key factor in outcomes.

Even though a large body of research exists on processes and outcomes (often referred to as process-product research) this generally does not intersect with resource-outcome studies. Researchers who spend their time looking at resources and outcomes have tended to rely on secondary analysis of existing data sources, rather than getting closer to schools and classrooms. Process-outcome researchers tend to be more interested in the more micro world of classrooms and generally are not concerned with the resources that must be brought to bear to make classrooms function.

A recent study by Elliott (1998) exemplifies the kind of work needed both to get inside the process black box and to link what is inside to both resource inputs and outcomes. Elliott linked data on resource inputs based on U.S. census data with process and outcome data (mathematics and science achievement scores) from the National Education Longitudinal Survey of 1988. The main resource variable was school district expenditures. This was conceptualized as purchasing services, such as teacher qualifications, smaller class sizes, and availability and condition of equipment, which were hypothesized as contributing to "opportunity to learn." The latter, in turn, were hypothesized as being related to processes, such as emphasis on higher order thinking and inquiry skills, emphasis on math computations and memorizing facts and emphasis on the relevance of mathematics and science, which are related to achievement. The model is thus one of direct resource effects and indirect mediating effects based on the translation of resources into processes. Thus, rather than simply being proxies for resources, variables such as class size and teacher qualifications were viewed as the consequence of resource inputs but related to the processes used and hence to opportunity to learn.

Elliott found small but significant direct expenditure and process effects. However, the mediating effect between expenditures and teaching practices was found only for science. Part of the positive effects of expenditures on achievement was accounted for by the mediating effects of teacher education and experience. The effects for science were stronger, with expenditures affecting classroom processes which, in turn, influence achievement. Elliott attributed this to both the existence of more variance in science than in mathematics achievement and to the greater demands of science teaching on resources and on teacher capabilities.

Elliott concluded that the results support the use of resources to hire more qualified teachers but that the effectiveness of these teachers depends on their use of effective teaching strategies. Elliot also argued that research is needed to more precisely pinpoint how resources are being used. In this respect, Elliott's work supports the position consistently taken by Hanushek that the key to resource effects lies in resource use.

In a similar, vein, Wenglinsky (1997) proposed a more elaborated mediating model, with expenditures broken down into teacher, per-student instructional, administrative and capital components. Different cost components were hypothesized to affect teacher-student ratio (the reciprocal of the usual student-teacher ratio), teacher qualifications and aspects of the school environment. In this study, the NAEP data base was combined with a national data base of cost

components. Using structural equation modeling,[7] Wenglinsky examined the effects of cost components on the teacher-student ratio, student behaviour in the classroom, and mathematics achievement in grades four and eight.

Wenglinsky concluded that expenditures affect the achievement of grade four students in two stages. First, expenditures on instruction and school district administration increase teacher-student ratios (effectively making classes smaller). Increased teacher-student ratios, in turn, increase average achievement in mathematics. For grade eight students, there is an additional stage, in which increased teacher-student ratios lead to a reduction in problem behaviours which, in turn result in increased achievement. In addition, Wenglinsky found that achievement was not associated with variations in capital spending, school level administrative expenditures or teacher education levels. While showing opposite results to many other studies on the teacher-student ratio issue, this study does help identify areas of expenditure that seem to be productive or non-productive.

3.7 Effective Schools

Paralleling, but rather independent of, research on classroom teaching and learning process and achievement is a body of literature on "school effectiveness." This literature is concerned mainly with school climate, leadership styles, school improvement planning and similar issues where the focus is the whole school rather than the teacher or classroom. The recent preoccupation in some quarters with school choice may be seen as an offshoot of the school effectiveness literature.

Research on school effectiveness identified a number of school factors related to achievement, including high expectations, positive teacher role models, feedback on student performance, student acceptance of school norms, strong leadership of the principal, an orderly school environment, frequent assessments of student performance and emphasis on mastery of basic skills (Levin, 1995). According to Levin, this body of research has been subject to a number of methodological criticisms and has tapered off in more recent years.

That is not to say that school improvement initiatives can no longer be found. Indeed, many jurisdictions now seem to have developed ways to encourage schools to develop school improvement plans. A prominent Canadian example is the Alberta Initiative for School improvement (http://www.education.gov.ab.ca/k_12/special/aisi/whatisaisi.asp). However, it appears as if such initiatives are now less research-based and more grounded in total quality management (TQM) and other management theories (Levin, 1995). In reality, this research is not particularly useful in attempting to elaborate the education production function because few of the factors that seem to be identified with school improvement are related to school resources or, more likely, no efforts have been made to examine the impact of resources on school climate and leadership factors.

[7] Structural equation modeling is a generalized version of regression analysis particularly suited to examining the direct and indirect effects of predictors on outcomes.

3.8 Post-Secondary Education

Much of the attention in human capital studies has been focused on the value of post-secondary education. Indeed, most of the studies reviewed in the section on the economic returns involved the individual returns post-secondary education.

That sector enjoyed substantial expansion from the 1960s to the 1980s, before a period of retrenchment in the 1990s as government financial constraints reduced the levels of available funding. This expansion was clearly related to human capital development and particularly to labour market demands and outcomes. Although calls are beginning to emerge for greater accountability (e.g. State Higher Education Executive Officers, 2005), there is a dearth of research on societal returns and particularly on the relationship of post-secondary resources to outcomes.

The recent CPRN review (Finnie and Usher, 2005) on measuring post-secondary quality has proposed a sequential model which closely resembles the production function schematic, presented earlier in this report. This model may be depicted as follows:

beginning characteristics → learning inputs → learning outputs → outcomes

The authors go on to identify several approaches to measuring quality, including periodic internal or external reviews of units or institutions, ranking systems, accreditation systems and student surveys. None of these seem to have been used to estimate the relationships suggested by the model. In particular, most quality measures use inputs and processes as if these were the outcomes. For example, the Maclean's system for ranking Canadian universities (Maclean's, November 7, 2005) places substantial emphasis on the number of faculty with Ph.D.s, entry averages of students, expenditures, class sizes and a host of other input measures in developing their composite rankings. This represents an explicit attempt to treat inputs as if they were outcomes. Only a couple of indicators, such as the "reputational survey," look at all like outcomes and these suffer from significant methodological difficulties.

Without a clear measure of outcome, it is difficult to conceptualize how a more detailed production function for post-secondary education could be estimated. Some of the studies cited earlier illustrate the point. Basic literacy measures or perceptions of the education-job skills match are not a substitute for the kind of achievement measures found in studies of elementary/secondary education. Outcomes in post-secondary education are much more differentiated by program and it is not at all clear how this diversity could be captured by any form of exit test. Many professions (accounting, medicine, law and engineering to name a few) use an elaborate system of examinations as part of the credentialing process, with the appropriate university degree serving only as an initial and not a final credential. However, none of these systems seem to have been used to measure the quality of the university experience in the form of differences in institutional success rates on the qualifying examinations or other such comparisons. Even an obvious matter such as class size, which varies enormously across programs and institutions, and which is an obvious point of contention, has not received the research scrutiny in post-secondary education that it has in elementary and secondary.

One area in which a small amount of work is emerging is that of the cost-effectiveness of new approaches to teaching, particularly distance methods such as correspondence or Web-based

courses. While this area has not been reviewed in any detail, there are indications that cost-effectiveness, as well as access, is a consideration in institutional decisions to offer such programs (e.g. Oslington, 2004; Jung, 2005).

4. Conclusions

4.1 The Human Capital Earnings Function

The individual economic return to higher levels of education has been so widely studied that there is now little dispute over the existence of positive effects. Education conveys an individual advantage additional to that conveyed by the overall economy or by family and other background factors. There seems to be little risk to an individual in making a decision to invest time, effort and money in pursuing higher levels of educational attainment.

Although there is some research, including a number of Canadian studies, on the place of ability, knowledge and skill in individual economic outcomes, debate continues over whether the education advantage is a matter of acquiring marketable attributes or whether it is mainly a screening device or a proxy for underlying ability. In reality, it would be difficult to argue that credentials are acquired independently of knowledge and skill acquisition. Also, ways in which knowledge and skills have been measured (basic literacy, perceptions of skill match) are likely inadequate to represent the specific competencies required in many high level professions or even trades or technology occupations.

Attempts to apply the human capital earnings function at the societal level have been less successful. While, in general, societies with higher levels of education are among the most economically advanced, it is not clear that this situation is driven by education or by other factors independent of or acting together with education. Aside from questions of whether the sum of individual economic gains is zero (some lose and some gain in the overall distribution of education and earnings), the overall economy is driven by many factors that have not been fully incorporated into the equation.

4.2 The Education Production Function

There is little doubt that human capital theory is having a profound impact on educational policy. Belief that we are in a knowledge economy that places an ever higher premium on education is firmly entrenched and certainly is a strong driver of educational policy. Most broad statements of educational aims refer to the knowledge economy or the importance of education for economic prosperity. A major thrust of educational accountability, reform and expansion initiatives, at all levels, is to improve the economic circumstances of individuals and to ensure the prosperity and competitiveness of societies.

In light of this, and especially in the face of limited resources for education, it might be expected that research would have something to say about the efficient use of educational resources. Unfortunately, the research on resource effects had not yielded many consistent results. This area remains controversial and there is little specific advice that can be given to policy makers on whether there is payoff from added resources or on how resources should be prioritized. In particular, there is little in the research that would tell us about the value of high cost initiatives or of major reallocations of resources. Some areas of cost increase, such as allocation of additional resources to the lowest achieving students, have been driven by human rights arguments and have not been investigated from a cost-effectiveness perspective.

As an example, although the class size evidence seems reasonably clear, the results are not particularly helpful for policy. In an experimental context, smaller classes in the primary grades yield higher achievement levels that seem sustained over several years. However, large reductions in class size are required to yield the desired effects. Moreover, broader studies of the place of class size among a variety of other factors affecting achievement, smaller class sizes generally shows either zero or negative effects, likely because the effects are so small as not to be detectable by the models used and because all sources of confounding cannot be removed.

What should policy-makers make of these results? Obviously, a public appetite exists for class size reductions regardless of what the research says. However, since it would be a costly proposition to bring average class sizes down to the levels at which payoff can be expected, the politically acceptable solution tends to be one of trying to achieve modest class size reductions, satisfying some of the demand while keeping costs to a minimum.

To take a second example, although teacher qualifications (years of education and experience) is a major driver of teacher salaries, the results for these factors are also not clear enough to permit any strong policy statement on the value of continued use of the current salary grid. There is some evidence that at least a few years of experience counts and that specialization is an advantage. However, there is almost no value to having higher degrees, even though this has significant salary implications. The problem here is that some means has to be found to create a career ladder for teachers, even if this has no relationship to outcomes. In the absence of performance indicators, education and experience take on a practical value as proxies for performance.

At the post-secondary level, we know even less about the effects of resources on outcomes. Most of the indicators data available on post-secondary education focuses on inputs and participation almost as if these were outcomes. Although studies of the human capital earnings function have focused mainly on higher education, to the extent that outcomes are measured at all this is done in highly generic ways such as through years of education, credentials, basic literacy skills or self-reported education-job match. The small amount of work which focuses directly on performance is based on the earnings function and does not look at educational resources or processes.

4.3 Where Do We Go From Here?

Human capital theory has clearly shown itself to be a useful foundation for research on the value of education. This theory may also be seen as a primary force in educational policy development. While it is possible to give other reasons for public support for mass education, it is difficult to imagine the system sustaining itself at ever expanding levels without its participants believing that there is economic benefit. What is interesting here is that this belief can be held even in the absence of evidence or in the presence of only weak evidence. This illustrates how policy can be, and usually is, influenced by many forces other than empirical evidence.

From an empirical research perspective, the ideal study of resource effects would be an experiment on the effects of schooling versus no schooling. Such an experiment is impossible in elementary and secondary education for obvious reasons. Virtually all children in the developed world are now exposed to a substantial period of schooling, at least through to secondary school

(though not to secondary graduation). It is possible only to look at differences between schools or systems. Since substantial efforts have long been made to minimize these differences, the variation in schooling available to study is thus quite small compared, for example, to the variability in family backgrounds or other characteristics that students bring to school. Comparative studies across systems, particularly countries, with widely varying resources are possible but this is also fraught with problems of confounding and of relatively few data points.

Comparative studies are possible at the senior secondary and post-secondary level because individuals can be found with widely varying levels of exposure to higher education, including no exposure. Indeed, this is the thrust of most research under the human capital earnings function. However, the selective nature of the post-secondary system, and the further selection factors in getting post-secondary education to the work place, introduce confounding factors that have not yet been well enough sorted out to determine the causal effects of higher education and especially the causal effects of what has been learned, as opposed to having earned a credential. Again, one could imagine an ideal experiment in which individuals are randomly assigned to post-secondary programs and the effects measured over time. However, it seems unlikely that any system or institution could be persuaded to conduct such an experiment.

In the absence of the ”definitive” experiment, what can be done to advance our understanding of the economic effects of education and particularly of the cost-effectiveness of particular resource allocations? In an earlier paper (Crocker, 2002), the author prepared a “wish list” of needed research on the education production function. The remainder of this section draws heavily from that paper.

4.4 Outcomes Definition and Measurement

First, almost all of the resource effect studies have used achievement in core subjects, typically reading mathematics and science as the outcome. While there may be considerable debate over what constitutes valid outcomes, the school curriculum extends well beyond these areas. For example, there would likely be agreement that skills contribution to health and citizenship should be taught. A current example is renewed emphasis on physical fitness, in light of the health risks associated with childhood obesity.

> *There is need for public and professional validation of outcomes, for priority-setting among outcomes and for research designed to assess public and professional views on the range of outcomes to be measured.*

Once some broader outcomes are clear, these can be measured and research can be directed to the effects of resources designed to achieve these outcomes.

This type of work needs to be extended to the post-secondary level, where there seems to be no consensus on core outcomes common to all programs.

> *There is a need first to identify and validate a set of common outcomes expected of graduates from core post-secondary programs.*

A good starting point for this might be the employability skills profile developed by the Conference Board of Canada (2000). Since this originally emerged in the context of a federal government “prosperity initiative” and was developed from extensive consultation with

educational and business leaders, this profile has been subjected to a validity process that would be difficult to duplicate. It would not be an overwhelming job to develop an outcome measure based on the elements of this profile and to administer this in settings such as post-secondary graduation, the National Graduates Survey or a survey similar to the International Adult Literacy Survey. Having information on performance on these elements would add significantly to the ability to distinguish the effects of years of education, credentials and skills

Beyond this, it should be possible to

> *make greater use of available information on trade and professional credentials to conduct research on the factors contributing to these competencies.*

While professional and trade organizations have a proprietary interest in the content and results of credentialing tests, it would not be unreasonable to engage such organizations in studies of the impact of results on these tests on economic outcomes. Indeed, professional organizations are in a position to track and gather information from their members on a long-term basis.

4.5 Use of Large Scale Surveys

Large scale surveys have long been used for research on the education/earnings function. Some use is now being made of achievement surveys, particularly NAEP in the United States and TIMSS and PISA internationally, to examine the resource/outcome relationship in elementary and secondary education. These have tended to be of limited use because the focus of these surveys has not been on resources and because of the limitations of what can be gathered from self-report questionnaires. The consequence is the need to use proxies for resources, such as student-teacher ratios or teacher qualifications.

Ideally what would be required is a resource number that could be attached to individual children, along with their achievement results. In practice, the best that could likely be obtained would be school level data or group data for children in various categories. For example it might be possible, with the appropriate design, to identify the level of resources attached to special needs children, those in advanced programs or the like. Realistically, there seems to be nothing in the design of current international surveys that would come close to this.

In Canada, several provinces now have more or less comprehensive student assessment programs, many of which are administered to the entire population at a grade level. Provinces also have large amounts of data that could be translated into more precise resource indicators. For example, the ratio of total teacher salaries to enrolment at the school level or per-student expenditures on instructional resources can be computed from available data. Some differentiation of resources expended on students within schools could also likely be made. Using such data would permit assembly of population level data that would be much more precise on both resource and outcome variables than anything now available.

> *There is a need for research specifically designed to develop and test comprehensive models of the factors contributing to achievement. The primary focus of such research should be on the path from resource inputs to processes to outcomes and emphasis should be placed on ways of diminishing the impact of student background and other contextual variables on achievement.*

4.6 Field Experiments

There is a limit to the yield of survey data in investigating causal relationships, and we appear to be reaching a saturation point in what can be learned from such surveys. No matter how sophisticated the statistical models, there will always be uncontrolled extraneous variables and lack of control over the variables of primary interest.

Education has little tradition of using randomized clinical trials, and those that are found have typically been small scale and somewhat artificial relative to the real world of schools. Nevertheless, examples such as Tennessee STAR illustrate what is possible when a jurisdiction decides that a major issue of resources and outcomes needs to be carefully examined.

There is something of a tradition in introducing new initiatives in education of conducting "pilot projects." These are particularly prevalent in curriculum implementation. However, these usually are biased towards success by trying the initiative first with the best teachers and schools with every intention of implementation regardless of the results. Despite this history, an opportunity exists to implement more rigorous designs in pilot projects. By field experiments we mean simply an experiment or quasi experiment conducted under realistic school conditions and on a large enough scale to be broadly generalizable.

> *There is a need for judicious use of large scale experiments in advance of major policy changes or program implementations, especially where significant resource allocations or changes in practice are contemplated. Using such designs in the context of pilot projects would be a desirable starting point.*

An obvious example of what is meant here is the case of integration of special needs students into regular classrooms. This is a large scale initiative, being implemented to a significant degree in all Canadian jurisdictions. The driving force behind this approach is human rights legislation and court cases which have entrenched the principle of having children placed in the "least restrictive" environments. Of the large number of studies of children with disabilities, almost none deal with the effectiveness and certainly not with the cost-effectiveness of different placements for such children. Indeed, the prevalent view seems to be that there is no empirical question to be answered here, but simply a human rights question. However, no service is done to these children or to others in moving ahead with an approach, especially a high cost one, which is not established to be effective in achieving desired outcomes.

There are sufficient numbers of precedents for long term large scale experiments in areas such as medicine to lead us to believe that experimental research can eventually become the dominant approach to answering questions about the impact of resources. Some indications are emerging that this approach may gain a foothold in education.

Part of the problem with education production function studies is that resource variables are typically measured in an unrefined manner. One of the advantages of experimental or quasi-experimental designs is that they frequently require more careful thought to the "treatment" variable than is possible with survey designs. Class size is a typical example. To begin with, student-teacher ratio may be only a rough proxy for class size. Class size has as much to do with how teachers are deployed in a district or school as with the student-teacher ratio. For example, it is not unusual to see a situation in which many of the teachers in a large school are assigned to

various kinds of specialist duties rather than to a regular classroom. One of the advantages of experimental or quasi-experimental designs is that they force us to develop more nuanced definitions of the "treatments" than are typically found in naturalistic studies.

4.7 Longer-term Longitudinal Studies

Most studies under the education/income production function have been of recent graduates, with graduate follow-up surveys being a primary tool. Similarly, most resource/outcome studies rely on resource indicators gathered at a particular point in time, even though outcomes are usually cumulative in nature. Longitudinal studies have the potential of adding considerably to the ability to examine these issues. The beginnings of a longitudinal approach can be found in Canada in such surveys as the Youth in Transition Survey. The question, of course, is whether such studies can be sustained for a long enough period to yield the desired payoff. Again, there is precedent in medicine, where long term follow-up studies are fairly common.

4.8 The Process "Black Box"

Educational resources obviously are not used directly to purchase outcomes. The model shown in Figure 1, and most similar models, shows an intervening "process" component between resource inputs and outcomes. What these models call "teaching and learning processes" represent the goods and services purchased with the resources available. These may be of greater or lesser quality, and we cannot assume that more resources will yield higher quality. Aside from a few elements, such as class sizes or qualified teachers, which have been used as proxies for resources where more direct measures have not been available, the process component has largely been ignored in studies of the education production function.

To again use the class size example, it is rare to see in studies of class size any reference to differences in what teachers may do in small classes compared to larger ones. To over-simplify the point, an argument can be made that to the extent that teaching practices are relatively fixed, for example, on transmission of knowledge, then class size should not matter. This is the common argument at the post-secondary level, where teaching to ever larger classes can be seen as a matter of technology (i.e. using more sophisticated presentation settings or tools or, more recently using the Internet). On the other hand, a common argument made by teachers is that smaller classes allow teachers to pay more attention to individuals. This implies that some form of one-on-one teaching is desirable and would be practiced if only classes were small enough. This, of course, raises the more direct question of whether more individualized instruction is better than group instruction. Some answers to that question can be found, but these are not generally considered in production function studies.

The time has perhaps come for research on process-outcome relationships and on resource-outcome relationships to converge. Some convergence may be possible in the context of large scale surveys, where data on both resource and process variables typically exist. Examples of how such work may be conducted are the studies by Elliottt and Wenglinsky cited earlier. Unfortunately, the process information that can be gathered by survey questionnaires is usually too limited to be of much use. One possible way to achieve such convergence would be to revive the kind of micro-level analysis that was typical of process-product research in the 1970s and to extend this to micro level analysis of how resources are used. The time now seems to be ripe to move away from reliance on large scale surveys and global measures of resources and to

establish a new research agenda, designed both to get inside the black box and to determine the effects of targeted resource allocations and uses on what goes on in schools and classrooms and how this mediates the education production function.

4.9 Prospects for Interdisciplinary Research

Much of the research on the education production function already has an interdisciplinary character. In particular, this is one area in which researchers from another discipline, economics, have put their minds to education. Educators have also used economic concepts, models and analytical techniques in addressing the issue of resource allocation and use. To a lesser degree, work of this nature has also occupied sociologists concerned with issues of equality of educational opportunity. The Coleman study itself, which many would consider the beginnings of research on educational resources, was the work of sociologists.

Despite these links, little of the research can be considered truly interdisciplinary in nature. There are few examples in which the authors of individual studies can be said to cut across disciplines, although some reviews and edited volumes have representation from the various disciplines.

Building an interdisciplinary research agenda has much to recommend it. For example, the tendency for economists to rely on global indicators of resource inputs could be tempered by advice from educators on the specifics of how resources are used. The political climate of policy-making could be addressed by political scientists who can bring to bear insights into why concepts such as human capital development can enjoy such currency, despite limited evidence on the social impacts.[8] Broader measures of outcomes are certainly required, which demands expertise in measurement, whose practitioners are to be found largely in psychology.

It is relatively easy to see the advantages of an interdisciplinary approach to the advancement of research in this area. It is quite another thing, however, to develop the interdisciplinary teams and networks necessary to address the research areas already mentioned. Such things do not just happen, and it is beyond the scope of any individual researcher to establish the needed connections. Nevertheless, there exist in Canada some models for developing interdisciplinary networks. The Networks of Centres of Excellence program, a joint effort of the three major granting councils, is one such example. Itself a model of how agencies involved in disparate disciplines can collaborate, establishing an NCE for interdisciplinary research on human capital development would be one way to develop a Canadian presence in this area and to bring life to some of the needed research on the education production function. This is not the place to bring forward a plan for such a network. However, the field is attracting sufficient interest and there is sufficient need to examine issues such as cost-effectiveness and the social impact of education that this would be an attractive area in which to develop a network.

[8] Recent research on social impacts is summarized in the paper by Craig Riddell in this series.

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