21st Century Learning

Promethean Education Strategy Group

Promethean Thinking Deeper Research Paper No.2

Learning Productivity: It is Time for a Breakthrough

Series Director: Riel Miller
Authors: Stefan Bergheim, Riel Miller, Ilkka Tuomi
Date: January, 2011
Sponsored by: Jim Wynn, Chief Education Officer, Promethean

Promethean Thinking Deeper Research Papers Series sponsors leading experts to conduct and report on cutting-edge thinking and state-of-the-art global academic/policy knowledge with respect to the role of new technologies (innovative tools and organisation) in meeting the challenges of learning in the 21st Century.

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Summary

Promethean Thinking Deeper Research Paper Number 2 argues that there are two forms of learning – one open and one closed. In turn, these two different forms of learning are associated with two different ways of understanding learning productivity and hence of achieving changes in the level of productivity. Making this distinction is critically important because it offers a new way to understand the challenges we face when we want to improve education, improve economic performance, improve well-being.

The Paper contains three sections, each devoted to elucidating the challenges and opportunities created by the significant changes taking place in the nature and place of learning in the world around us.

1. **Section 1** introduces the main topic, learning productivity and explains its importance for both education reform and economic conditions.

2. **Section 2** delves in-depth into the question of productivity, how we define it and measure it, helping to distinguish open and closed learning.

3. **Section 3** builds a bridge to the changes taking place in the way learning and education relate to quality of life.

The Message:

Today the interaction between learning that occurs without predetermined goals and learning that is targeted to achieve known outcomes is ushering in a leap in learning productivity. Learning to learn is taking centre stage. Not just because lifelong learning has been a slogan for fifty years, but because now it is happening. Only not exactly the way we expected. Learning is becoming a constant and integral part of everyday life, at work, at home, amongst friends, and on the move, people are plunging into creative situations. Moments when the answer does not exist, it has to be invented, usually on the spot and in ways that turn the process into the product – a lived learning experience.

Of course new and amazing tools are enabling this shift, but the real change is the economic, social and decision-making realities entailed by activities like creating your own lifestyle, inventing low carbon villages, or connecting innovation networks. And the best news of all is that learning-to-learn probably offers increasing returns to scale – the more we do it the better we get. This is the key to making the leap to the next stage of knowledge creation and sharing for traditional school systems, universities, enterprises, public institutions and all the people who are just doing-it everywhere, all-the-time, just-in-time.

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Introduction and Overview

By Riel Miller

The first paper in this series, Promethean Thinking Deeper Research Paper Number 1 (Parts 1 to 3), was published in December 2010. Its main message was that there is huge potential for a leap in learning productivity. The equivalent of being able to graduate a student with all the knowledge and skills of a quality high school diploma in 10 as opposed to 12 years. This is a straightforward type of productivity jump – the same output for less input.

Imagine the savings in time, classrooms needed, total salaries paid, and overall education spending. If we take only total global public expenditure on education, estimated at 2.6 trillion dollars in 2007[1] , as the basis for comparison, then a 17% improvement in productivity would liberate over 442 billion dollars. This is much more than enough money to achieve all the Millennium Development Goals, estimated to cost only 28 billion dollars more per year[2], including Goal Number 2 which is primary education for all.

Projecting savings from imagined productivity gains is easy, the hard part is figuring out how to make them happen. This is the focus of the Thinking Deeper Papers.

The core argument is that a leap in learning productivity throughout society, in schools, universities, workplaces, communities, and families, is possible if we understand and act on two fundamental changes taking place in the world today.

- The first change is the growing importance of what might be called 'open learning' for economic, social and governance activities.

- The second is that the methods for understanding and acting on the potential for productivity improvements both within and between open and closed learning systems is improving.

Looking at the first point, what is open learning and why is it becoming more significant?

Put simply open learning occurs when the outcome is unknown. This is learning as a journey, a series of experiences and experiments, with knowable starting points but only emergent, novelty filled end-points. Closed learning occurs when the knowledge to be acquired is defined in advance – the goal is clear and so too, in many circumstances, the resources and rules for getting there.

One example of this contrast is between the open learning of the quest for self-identity and the closed learning of schooling. The open learning of discovering who you are or detecting the potential of the present have no pre-determined outcomes. No one can tell you what kind of person you will become. There is no way to know in advance. All you can do is live and seek and attempt to assess, through interaction and reflection, where you have been, what you have learned, and who you have become. School, by way of contrast, has a clear set of outcomes – passing or failing the test tells the story (which does not mean there is no open learning happening in schools or closed learning playing a role in open learning discovery – just that two distinct and often inter-dependent logics are at play).

Open learning and closed learning can generate similar capabilities – a better understanding of knowledge creation and acquisition. While closed learning emphasizes internalization of existing knowledge and the development of pre-defined skills and competences, open learning emphasizes the process of learning itself. Open learning occurs in social networks where learners gain and construct new knowledge and capabilities. It is often self-directed and problem-oriented. It is self-motivated, grounded in the learner's personal context, and often it leads to very rapid competence development. The learning-to-learn that can augment closed learning and vice-versa.

The reason that open learning is now becoming more important is that humans are increasingly living in

situations where the goals cannot be defined in advance. This is true for what it means to be a citizen, a member of a family or a worker in an innovative team. Preconceived models borrowed from the past are becoming less useful, less satisfying and less convincing. In these circumstances convergence and catch-up, measurable by a test that shows whether or not you have crossed the finish line, are inadequate since the key is to invent new models – ones that get us beyond today's impasses such as climate change, industrial unemployment, debt or destructive growth, and fear of the future. Open learning and the disciplined imagination that goes with it is, in these transformative times, ever more central.

Of course learning in all its forms has always been the greatest source of human progress – individually and collectively. Up until recently the role of learning was like a ratchet. As people from one generation to the next re-learned how to read, write, obey laws and collaborate the whole of society could build on past experiments and discoveries. Yesterday's evolutionary outcomes served as platforms for current action.

Now something else is going on. We still stand on the achievements of the past, particularly those that sustain our tools and methods for assuring subsistence. But, beyond subsistence another form of learning kicks-in – less about the progress that creates ever more fuel-efficient cars or lighter computers – more about personal knowledge acquired through interaction and reflection. Meaning not output is becoming dominant.

Up until recently the fact that there are two different basic forms of learning, one closed and one open, did not have much apparent economic significance. But as the search for meaning starts to supplement survival as the preoccupation of human activity, at least for part of humanity, then open learning begins to occupy a larger share of what we do and what we care about.

Now, around the world, open learning is beginning to move to centre stage, calling on closed learning to share its former dominant spot. As a result it is becoming more important to pay attention to the nature and role of open learning as well as the relationship between systems of open and closed learning.

These observations lead to two pivotal conclusions:

1) the growing economic and social importance of open learning has potentially major implications for the processes, tools and practices of closed learning; and

2) that if addressed properly, by avoiding the errors that arise when we mistake one for the other and the missed opportunities that occur when we fail to see the inter-connections, there could be huge productivity gains in all learning systems.

In other words the challenges facing closed learning systems, like schools, may be significantly different if we understand the nature and role of open learning systems. Equally important, the role and impact of closed learning on economic and social well-being may be changing as more and more of what counts as economic and social value comes to depend on open learning capabilities and results.

For instance it may turn out that one of the most effective ways to meet the quality challenges faced by school systems, even bump up PISA rankings, could be to invest in the infrastructure of transparency and trust needed to facilitate the functioning of open learning systems. Not only because the learning happening outside the bounds of pre-known knowledge changes what known knowledge is deemed important but also because the capacity to learn generated by more effective open learning can significantly influence the efficiency of closed learning processes. For instance, gains in the efficiency of ambient open learning can have spillover effects on closed educational outcomes by: providing teachers with new sources of inspiration for both themselves and their

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students; changing the relationship of students, families and firms to what they need from school; facilitating the restructuring and adaptation of curricula content and pedagogical methods including technology; and, perhaps most importantly, facilitating personalization of learning – not just by improving supply side diversity and customization capabilities but critically developing the capacity on the demand side, of learners, to select and assess their own paths.

Such inter-systemic connections do not always appear evident when the focus is on intra-systemic problems and changes. Today the attention of many people is focused with urgency and dedication to making closed system learning more efficient. This is a worthy task. Made all the more important by the perception that closed learning systems and closed industrial production systems are inter-dependent, hence the competitiveness and hence prosperity of a country depends on winning this race.

But what if another economic, value creating set of activities started to gain in importance? This is an economy that creates value but is undetectable using the models and variables, the accounting systems and signals of yesterday's successful industrial era. Like when industry took over from agriculture the new is hidden within the old. Certainly the emergent unique products and identity expressing experiences are made cheaper, easier and faster, by the underlying closed industrial systems of mass-production. One depends on the other, but the non-mass products, the unique experiences that express who you are and what you do as you yourself discover it, these activities also depend on the existence and capabilities of open learning.

Over the following pages Promethean Thinking Deeper Research Paper Number 2 explores the nature and role of learning productivity, how it is enhanced and why it matters. The goal is not to exhaust the profound depths of these topics nor to provide pre-packaged, bench-mark solutions that can be mass-produced to solve the problems of policy-makers, practitioners, and the developers of open and closed systems of learning. Particular solutions always depend on the practical context and specific situations. Our aim is to invite a reconsideration of how to best achieve stated goals, like improving the productivity of schooling and ensuring that more and better schooling improves quality of life. Many of the issues and challenges discussed in this paper are profound. That is why we need to think deeper.

Table of Contents

Series under the direction of Riel Miller
Authors: Stefan Bergheim, Riel Miller, Ilkka Tuomi
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Paper No.2 - Section 1:
Why Learning Productivity Matters
By Riel Miller

"We are in one of those eras when, with our certainties shattered and our traditional ways of thinking shown to be impotent, everything has to be rebuilt and reinvented. We are in an era when the central question for politics is what model of development, what model of society and civilization, we aspire to live under and bequeath to our children."

Nicolas Sarkozy,
President of France, 2010,
Foreword to Mis-measuring our Lives:
Why GDP does not add up.[3]

Productivity is a powerful term; one that is deeply etched into the history of the last few centuries. At its simplest the idea of productivity can be defined as the efficiency with which inputs (effort, resources – time and raw materials) are turned into outputs (products, achievements – quantity and quality)[4] . Looked at in practical terms it is the level of society-wide productivity that, in large part, determines the well-being and wealth of a society[5]. And it is the rate or speed of productivity change that determines how quickly a society surges ahead or falls behind any particular level of output.

To determine changes in productivity levels we generally asked the question, do efforts to grow food, cook a meal, build a home, preserve and invent knowledge, take up more or less time and resources? In situations where the conversion of effort into output is very inefficient (low productivity) then there is the risk of hunger or over-work just to assure minimal levels of survival or quality-of-life. When the conversion is efficient (high productivity) then there is a better chance that food will be abundant and people will have time and resources to diversify their activities beyond those that cover the bare necessities for survival.

The efficient conversion of inputs into outputs (a high level of productivity) can be an effective way to achieve physical prosperity. To get to a high level of productivity requires the investment of time and effort to improve efficiency. The pursuit of positive rates of productivity improvement is a ubiquitous challenge, for a person trying to cook a "better" meal, a firm attempting to cut costs or create a new innovative product, or the residents of a planet trying to preserve an eco-system.

Over time, with a lot of experimentation, many failures and some successes, humanity has stumbled upon a number of ways of improving productivity – from better systems for establishing transparency (comparability) and legal systems that reduce transaction costs (facilitate investment) to peer review (scientists, restaurant critics, etc.) and common accounting frameworks (pricing and ledger rules, stock markets, etc.). At the core of all of the conscious, explicit methods for improving the efficiency with which inputs are turned into outputs, is measurement.

The basis for determining if one way of doing things is more efficient than another is to compare the quantity and quality of the inputs, such as raw materials, tools, human effort, etc., to the quantity and quality of the output. Does the selection of one seed over another lead to more bountiful crops? Is one technique for making steel of the same or better quality faster than another? Is one chef producing more appetizing meals at the same cost as another chef? Is one country able to generate a higher level of per capita GDP than another? Answering these questions helps to determine if particular ways of

doing things are more or less efficient. This is the basis for understanding productivity and what leads to its improvement.

Comparison, refinement, experimentation, and judgment – all depend on the ability to evaluate and compare. Measurement allows this to happen. As the renowned economists Stiglitz, Sen and Fitoussi (2010) recently put it, "what we measure affects what we do. If we have the wrong metrics we will strive for the wrong things." And, reciprocally, what we strive for will play a large part in determining our metrics. When physical survival, the adequacy of food supplies, water and bodily security are paramount the metrics follow suit. When trade and status are the dominant societal goals then the metrics expand beyond physical survival to include new measures of both inputs and outputs.

Today, as the opening quote from the President of France makes unmistakably clear, it is time to reinvent the metrics. But this begs the question of what is the goal? Measurement to what end? What is the output, what is the input and how can the reinvented metrics be pertinent to improving the efficiency of the processes that convert inputs into outputs?

These are deep and difficult questions that naturally have many different and equally valid answers. However, for the purposes of this series of Promethean Thinking Deeper Research Papers the central question is about learning – of all kinds.

Throughout the Thinking Deeper series learning is defined as all human activity (solo or in groups) that gives rise to knowing. From this perspective learning is not the accumulation of data in a book or the millions of hours of accumulated learning that is embedded in a television. Learning is a cognitive process conducted through different forms of inter-action, testing, and feedback (introspective or extrospective). Learning can be both hierarchical (less to more – bottle washer to rocket scientist) and heterarchical (uniquely meaningful or incommensurable – what makes me happy).

This definition of learning is purposefully as broad and universal as possible. It encompasses the most brilliant and refined insights that occur to scientists and leaders as they experiment as well as the most banal but still meaningful steps of a child that starts to read a text and a punter whose betting helps reveal the intricacies of horse racing or football matches. But it also goes beyond commensurable forms of knowing to include learning that has no common quality for comparison. To borrow the terminology of national innovation systems[6] – learning encompasses know-how, know-what, know-who and know-why. To borrow the terminology of communities-of-practice learning happens in practice as doing, in experience as meaning, in community as belonging, and in identity as becoming.[7]

From these perspectives learning cannot be defined for the purposes of input-output measurement in the same way as a simple material product or a testable "competence", even if we can test to see if someone knows how to bake a cake. This is because learning is not separable from process or context.

Learning is interactive, collaborative and related to what is happening at that moment (such as distractions). Learning is a process, with quantitative and qualitative attributes that we all understand intuitively and implicitly because we all do it. We know when we are creating knowing. The challenge here is to make it explicit in a way that allows for an analysis of the "productivity of learning[8]."

One approach, well established in the field of economics, is to use a common measure of value to provide the metric for comparing inputs and outputs. The elements necessary to make such 'economic measurement' work are quite clear: first value is equated with utility, then the value of such usefulness is quantified by a price, which in turn is set through the willingness to pay as expressed in practical terms by actual market choices (sellers and buyers), and last but not least the price can be expressed in a generally acceptable numeric unit such as money that is believed to be a way of measuring value now

and in the future. On the basis of this set of logical and practical equivalences it appears much easier to examine the efficiency with which a production process converts an input into an output and to also compare the outputs. However, as economists and everyday shoppers know such equivalences may be easy to establish in a perfect model but turn out to be very difficult in a world of very imperfect information.

Furthermore inputs and outputs, processes and outcomes, have many different quantitative and qualitative dimensions. Some of these dimensions can be measured in ways that offer a common hierarchical denominator, like kilos or test scores, slower or faster throughput, higher or lower profits. But there are many aspects of inputs and outputs, processes and outcomes, that are not only difficult to measure using a common metric, because it is difficult to establish shared definitions (a good restaurant for one person might be a poor one for someone else), such 'utilities' are actually incommensurate. Local, momentary, personal value is heterarchical and cannot be made comparable.

Which brings us back to reinventing metrics and the point of this Thinking Deeper Paper Number 2. In this Paper the aim is to continue the Thinking Deeper conversation about learning productivity by reinventing the measurement of learning outputs and inputs. The next two sections offer brief summaries of how to address this task by leveraging the insights from recent cutting-edge work on the relationship of learning to productivity and to aggregate indicators of social well-being. This work helps to situate the important role of assessment systems that enable learners to know if they are creating and accumulating knowledge – a topic addressed in Promethean Thinking Deeper Research Paper Number 3.

The aim of bringing together all of these perspectives is to advance the discussion of three inter-related questions – that set the stage for policy and organizational innovation:

i. What is the basic idea of productivity and wealth from an economic accounting perspective? And what roles have and might education and learning play in value creation?

ii. Can the relationship between education systems and wealth creation systems be redefined and how might such a changed relationship impact on the productivity of learning?

iii. What are some of the changes in collective conditions, including those that might be created through explicit policy choices, that might alter the underlying systemic nature and relationships of wealth, productivity, and learning?

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Paper No.2 - Section 2:
Productivity and Learning
By Ilkka Tuomi

Today, the concept of productivity is most frequently used in its macro-economic sense, as a measure of efficiency in converting aggregate economic inputs into outputs. This model of productivity has its roots in engineering sciences. In engineering, the starting point is, by definition, a deterministic mechanical model of the world: Until the machine breaks, it fulfils a pre-specified function and converts predetermined inputs into predetermined outputs. Although the machine may generate heat, noise and other by-products and side-effects, these are irrelevant for the focal production process, and usually not accounted for. In this model, it is easy to accurately measure inputs and outputs, as they are pre-defined as a part of the process. This is also the industrial factory model, where raw materials are mixed with machines and energy, and turned in the labour process into valuable products.

This industrial notion of productivity is a powerful tool for assessing and improving deterministic systems where the goals, resources and rules are given in advance. However this way of understanding productivity is not only inaccurate but potentially misleading in the context of production processes where the outcomes are unknown and unknowable in advance. In these production processes we do not convert pre-specified inputs into pre-determined outputs. Thus the conventional idea of productivity does not work, and we have to seek new ways of defining inputs, outputs, and the organization of productive processes. Of course, as long as deterministic production processes, with known goals, resources and rules predominate, then the search for ways to improve mechanistic productivity takes centre stage. However when the point of the process, the outcome from investing time and effort, tools and capital, is unknown or open, then the ways in which we define, capture and use the idea of productivity must change.

Up until recently the former, mechanistic notion of productivity has been applied to learning, particularly since much learning seemed to be occurring in the factory like school setting. However as open learning becomes important at a social level and the economy starts to operate in a new mode then productivity of learning cannot be understood by simply exporting conventional economic productivity concepts to learning contexts. The macro-economic productivity measures have to be revised, and we have to more explicitly recognize the role of open learning in value creation. In such an open learning-based innovation economy, we produce value not only by refining pre-given raw materials and inputs. We do not only refine value by mining, extracting and purifying existing value; we also create it. We produce valuable things out of thin air, as it were, where they did not exist before and were not anticipated in advance. As a result, the economy and the space of valuable things expands. Although basic needs for food, shelter and survival still remain important, an increasing share of value production now occurs in domains that simply did not exist before.

In modern economics, the impact of learning on productivity is only partially accounted for. Learning in general is a major driver for productivity improvement. Its impact is visible on the macro-economic level and in socio-economic progress. Learning, however, can also speed up the learning process itself. The productivity of learning is therefore one of the important determinants of the rate of change from one level of productivity to another. From this perspective not all learning is good, and sometimes increasing the rate of change from one level of productivity to another requires unlearning. In general, however, learning leads to the accumulation of capabilities, and the acceleration of learning processes.

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A closer look at research on learning reveals several important points where our current concepts of productivity should be refined.

Productivity of Learning

In the economic sense, productivity is simply a number that we get by dividing output volume by the volume of inputs, and it measures the efficiency of the economic production machine. When innovation becomes important, volume needs to be adjusted for qualitative changes, but otherwise the picture remains the same.

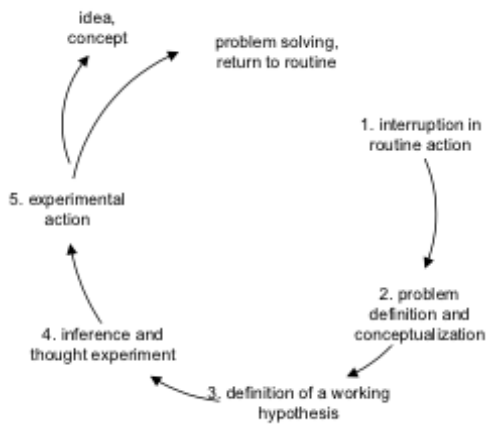
In the contexts of learning, we have to open up this black box of productivity. What, exactly, happens when we become able to do things more efficiently and effectively than before?

The main drivers for productivity change can be located in learning that occurs at social, organisational and individual levels. Current theories of learning emphasize linkages between these levels.

A useful entry point into the black box of learning productivity is John Dewey's description of the learning process. Dewey argued that the cycle of learning starts when our routine action is interrupted, and we become aware of something that does not fit with our expectations. This leads to an activity where we define and conceptualise the problem at hand. To solve the problem, we then define a working hypothesis, make inferences based on it, test whether our hypothesis works, and, if that is the case, generate a new model of the world that allows us to return to routine action. This cycle of learning is depicted in Figure 1.[9]

In Dewey's model, efficiency improvement occurs when we learn to recognise and reinterpret problems, formulate tentative solutions, model the world with improved models, test our models and re-frame and re-conceptualise the world. Learning, thus, is not only about acquiring knowledge about a world; it is also about constructing models that allow us to act effectively.

Figure 1: *Dewey cycle of learning.*



In this model, productivity of learning could be interpreted as the speed of the learning cycle. The cycle can be blocked or delayed at each step, and the movement from one step to another may require excessive effort. If the learner has good capacity for each of the steps, the learning process is fluent and leads to efficient knowledge creation.

Learning productivity would then be defined as a process characteristic, as a capability to learn, independent of specific pre-given inputs and outputs. We are also in a position to distinguish two types of learning cycle: a) those that are inscribed and structured by predefined outcomes, knowledge to be acquired that can be defined in advance, or closed learning; and b) learning cycles that begin from a knowable starting point but have no predetermined specific content, the knowledge and its meaning are emergent.

The key observation from Figure 1 is that the process that leads to efficient learning has many qualitatively different sub-processes that require different types of capabilities and inputs. Many of these capabilities and inputs are incommensurable and cannot be aggregated in any simple way. Many of these inputs also cannot be substituted for each other. They have to be measured using a multi-dimensional framework of measurement.

The Nature of Learning Inputs

It is possible to explore the above model in greater detail and locate key inputs for each of the phases of the learning cycle. Here we simply illustrate some main points, which also highlight the difference between learning productivity and conventional models of economic productivity.

Dewey's model was based on his pragmatist and action-oriented view of knowledge and cognition. Thus the first phase of his learning cycle is deeply rooted in action. We cannot hit the boundaries of our cognitive models unless we are able to enact them in practical settings. In this stage, input measures thus need to capture the richness of the context for action.

In the problem definition phase, accumulated learning and creative thinking become important. We use existing concepts and conceptual systems to frame problems, and sometimes we need to extend and move beyond existing concepts to find effective ways to formulate problems.

A good problem definition often already incorporates a hypothesis of its efficient solution. In the third phase of Dewey's cycle, a clearly articulated working hypothesis emerges, which is then used in this fourth phase to formulate a predictive model that can be tested to verify the hypothesis. In this stage inputs could be called "methodological." Science and scientific methods to a large extent have specialised in maximising the efficiency of these stages.

To verify improved models of the world, we have to be able to test them. In this stage, capability for experimentation becomes important. When improvements are local, experimentation may consist of simple tinkering or a more methodological hypothesis testing. In general, however, experimentation requires changes in established routines and social practices.

Although the above learning cycle is easily interpreted as a model of individual learning, it is important to realise that its stages are both directly and indirectly social. Routines and practical action transpire in a social context that makes the activity meaningful. Problem definition often relies on socially shared conceptual systems and socially distributed cognitive and material resources. Problem solving methods and tools are learned in social contexts and communities of practice. The inputs for the learning process, thus, are, in general, socially and materially distributed, and cannot in any simple way be associated with individual learners. To get cognitive tasks done, we borrow cognitive capabilities from our social and material environments.[10]

Learning assessment often misses this crucial point. A doctor without her instruments and a patient does not know how to operate on a patient. A software programmer without a computer and software development tools does not know how to program, and effective programmers often ask for help from their extensive networks of specialist colleagues. The attribution of skills and knowledge to specific individuals often indicate the capability of an individual to mobilize skills and knowledge embedded in social and socio-technical networks. Knowledge is not something that exists in some pre-fabricated form inside an individual's head. Systems of knowledge rely on vast repositories of socially distributed meaning and conceptual systems, and as knowledge materialised in complex socio-technical contexts of social practice.

Dewey's learning cycle implicitly focuses on problem solving and it starts when we become conscious of something that does not fit our expectations. In the innovation economy, an important role is also being played by the skill to see problems where others' do not yet see them. In innovation research such latent problems have been called "presumptive anomalies." Furthermore, creative innovators can also imagine latent "presumptive opportunities" that improve the efficiency of existing practices and processes even when there are no anticipated problems on the horizon.[11]

Learning Outcomes

The productivity of learning, however, cannot be defined simply as the speed of the learning cycle. We also need to be able to measure the outputs of the process. In Dewey's model, some problems are trivial, whereas others are fundamental. Learning can be about incremental improvement, or it can be about radical re-framing that opens up entirely new domains of thinking and acting.

Incremental improvement, indeed, lies at the foundation of the traditional concept of productivity. Incremental improvement implies that we do more effectively more of the same. In this special case, we can fix both inputs and outputs, and measure improvement simply by looking at the efficiency of conversion of given inputs to given outputs. The underlying assumption is that we do not have to ask what is the value of the outputs. In fact, conventional productivity analysis struggles to keep values constant. It uses sophisticated statistical methods to find discount rates that account for relative shifts in values, as they are expressed on the market. This is the only way that conventional productivity measurement can focus on a single number that expresses change in conversion efficiency.

This incremental approach does not work well in the domain of learning. Learning creates qualitatively new capabilities to think and act. As Vygotsky argued long ago, learning produces new modes of thought that make qualitatively new ways of thinking and cognition possible. Thinking that relies on complex conceptual systems such as languages or mathematics enables us to see the world in a way that would simply be impossible without these systems, making new forms of abstraction, generalisation and inference possible, and opening new avenues for thought and further learning.

Here we face a developmental dynamic that is profoundly different from traditional economics. The logic of classical economic theory was organised around a key social problem: how to get more output from a limited set of scarce resources. Learning, however, leads to expansion of the set of currently existing valuable things and activities. Where there was no value before, there is value now. Growth does not happen only by increasing the volume of already existing production, but it also happens through the expansion of the domain of value itself.

For one person, a piece of rock may be a piece of rock; for another it may reveal a gold mine. Inputs may remain the same, but the capability to make useful and valuable distinctions makes a difference. These distinctions are generated in the process of learning. Whereas traditional economics took scarcities and diminishing returns as obvious and natural starting points, in the expansionary domain of value creation the fundamental scarcity is our limited capacity to imagine ways to make the world more valuable. Strictly speaking, it may, of course, be quite inaccurate to label our capacity of imagination as a "scarce" resource, as we rarely run out of thoughts simply by thinking.

Measuring the Value of Learning

We then need to ask what is the value of the things we have learned. This puts the focus on an issue that is highly problematic for many economists. Although the question of value was extensively debated in the 19th century, many economists now think that the biggest victory of economic theory has been its success in avoiding questions about value. In neoclassical theory, value is simply defined as an economic value that is expressed on the market through prices. It is admitted that the prices are influenced by a multitude of individual value judgements, but the theory is designed to work without knowing these.

Learning, however, is inherently contextual and subjective. From an economic point of view, the present value of something that we learn could be defined as the stream of all future benefits that we derive from that learning. Our capabilities to derive benefits from learning investments, however, greatly depend on many idiosyncratic factors, for example social and historical contexts and the life-path

of the individual learner. There is no market that could set a price for the value of such investments.[12]

Learning, thus, cannot be valued using the theoretical framework of mainstream economics. The question then is whether we should exclude learning from economics because it does not fit the requirements of the theory, or whether we should revise the theoretical framework. Given that learning and innovation are increasingly important in present-day world, the latter alternative looks more promising.

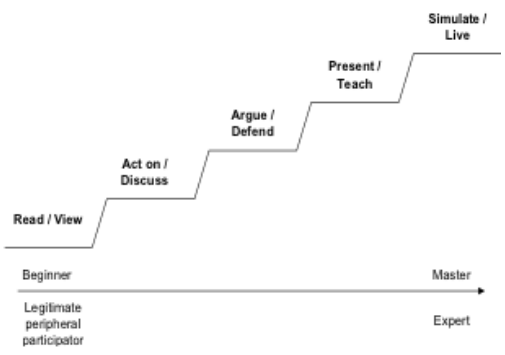
One relatively straightforward approach would be to by-pass neoclassical marginalist assumptions and start from a capability-based framework. The capability-based approach, as developed by Sen, is fundamentally based on the idea that individual contexts make a difference. In this framework, we could define the value of learning as expansion in the individual's capabilities. When a person becomes able to do things that she or he has a reason to value, learning has created value.[13]

This suggests a strategy for solving the challenge of measuring output value of learning processes. It obviously is not the final answer. The key observation here, however, is that there is an approach for measuring outputs that is based on different assumptions than most current productivity studies, and that this approach is conceptually compatible with the characteristics of learning. In the capability-based approach, learning is not an anomaly; instead, it is a driver of development.

Measuring the Volume

In the traditional approach the "volume" of learning outcomes has been measured as a fraction of a pre-defined stock of knowledge. In this view, when a student has learned all there is in a text-book, there is nothing more to learn. Assessment is about measuring the fraction of internalised knowledge.

Figure 2: *Levels of knowledge engagement.*
Source: Tuomi (1999), p 395



This approach fails on several grounds. Perhaps most importantly, it assumes a purely representational view of knowing. This can be usefully contrasted with more performance-oriented views.

One such performance-oriented approach to assessing learning outcomes was proposed by Dreyfus and Dreyfus (1986, 30). In their five-level model, novices become advanced beginners, competent actors, proficient actors, and eventually experts, at each stage showing specific capabilities to operate in the domain in question. A similar approach was adopted by Davenport (1997, 92), who focused on levels of knowledge engagement.

Interpreting the Dreyfus model in a Vygotskian context and using the terminology of the knowledge engagement, we can represent the level of knowledge development as in Figure 2. The first level of expertise development consists of the capability to meaningfully observe activities in a specific knowledge domain.[14] On this first level, novices are, for example, able to read texts related to the domain. On the second level, the developing expertise enables the actors to act on and discuss their views in the specific domain of expertise. On the third level, the actors become able to take positions and they also can at

least partially understand alternative positions regarding knowledge claims. This enables them to argue for and defend specific knowledge claims. The fourth level of expertise emerges when the actor starts to understand the other actors' possibilities for learning. On this competence level, the expert becomes able to present, teach and guide others toward higher levels of expertise. The fifth level, in turn, enables the expert to play with alternative hypothetical models in the domain, thus also enabling further development of knowledge.

The question: "How much have you learned?," could therefore be answered by determining the learners level of performance. Such a model has a natural link with the capability-based approach discussed above. It also highlights the point that the learners are not "final consumers" of learning; instead, through learning they gain productive capabilities.

The Impact of Learning on Productivity

Based on the above discussion, we may then ask what are the implications for conventional approaches to analysing and understanding productivity.

First, in much of extant productivity research, inputs are represented without much internal structure (Tuomi, 2004). Labour, for example, often appears as a single number that aggregates working hours, equivalent working days, wages and salaries, or something similar. Many influential studies start from the assumption that labour productivity is inherently constant and there is no learning. In many countries, output in the service sector is measured by the amount of labour inputs, which means that, by definition, there can be no labour productivity improvement.

In more practical business contexts, the incremental impact of learning has been extensively discussed in the context of "learning curves," which are widely used to estimate production costs. Theodore Wright introduced the term in 1936 in his study on cost developments in aircraft industry. In its original form, the learning curve represents the diminishing effort needed to repeat things that one has already done before. First time is more difficult than subsequent ones, and practice increases the efficiency of routine work. In shipbuilding for example, as the number of ships produced by a shipyard doubles, the production cost typically decreases by about 20 per cent

Research on process innovation has studied in great detail the types of innovation and learning that underlie learning curves. In general, process innovations are based on optimising existing processes. Many of these innovations could be called "parametric innovations."

Output growth, however, also occurs through the creation of new markets and new product concepts and categories. When new product categories emerge, they also define qualitatively new criteria for product performance. These new performance criteria are typically not measured using the old systems of measurement. For example, traditional benchmarks for computer processing power do not say anything interesting about the usability of social computing applications. Social computing application such as Facebook live in a different part of value dimension space than the one defined by the number of calculations a microprocessor can do in a second. Although productivity studies now heavily discount improvements in microprocessor performance, they remain rather blind to significant growth areas of the present-day economy.[15]

Productivity studies also typically assume that production inputs consist of a small set of independent inputs, such as capital, labour, energy, materials, and services (KLEMS). Labour, however, becomes productive only when appropriate combinations of inputs are used. Many investment goods are what could be called "composite goods" and productivity studies often count investments in only one element of the composite. For example, many studies on the productivity impact of information and communication technologies focus on investments in computing hardware. In practice, computing hardware

becomes productive when it is combined with software, production networks, and the people who have the skills that make productive use possible. Sometimes the required skills can be associated with labour, but often computer systems are also used to outsource work to customers and consumers, who are not accounted for by productivity studies.

The mainstream economic concept of productivity therefore remains agnostic about the causal factors or drivers of productivity change. Economic theory, in itself, does not say much about the sources of productivity change.[16] The situation is the same as with a steam engine: You can measure the efficiency of the machine by measuring its inputs and outputs but you need a different theory, in this case thermodynamics, if you want to explain how the efficiency can be increased. Changes in the productivity number may indicate that something is happening in the production machine; they, however, do not say what exactly is happening. To understand the sources of productivity, we need to understand learning.

At present, state-of-the-art economic theory of productivity lacks the conceptual structure that would allow us to meaningfully talk about the types of valuable outcomes that learning creates. This is an important challenge today when learning and innovation increasingly dominate economic change. Learning is the main driver for productivity change, and productivity of learning to a large extent determines the speed of productivity improvement. Robust theories of productivity therefore need to be built on robust theories of learning.

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Paper No.2 - Section 3:
The Role of Learning for Human Quality of Life
by Stefan Bergheim

Over the past years, there has been renewed interest in the question what a good society looks like, what a high quality of life means and what kind of future we would want to live in. Education plays a central role in answering these challenging questions. Part of the discussion is about the best way to measure relevant inputs, outputs and outcomes. At this stage, there are many pointers, some trends but no consensus yet.

As will be shown below, theoretical analysis, empirical estimates and concrete examples from schools and cities indicate four trends that are calling into question the current ways of describing the social systems around us:

- First, the focus is moving away from material issues such as money and income to broader priorities and new measures of success for nations, communities, companies and individuals.
- Second, only joint efforts by many different scientific disciplines such as psychology, sociology and economics will be able to provide us with a fuller and dynamic understanding of good quality of life and good education – with components and weights changing over time.
- Third, governments at all levels, civil society, researchers, companies and other actors will have to work together to move us forward. This requires new communication skills, but it will produce shared norms and rules as well as the necessary new institutions.
- And fourth, the measurement of relevant issues such as mental wellbeing or satisfaction with work is lagging behind what people deem important.

Combine Insights from Different Disciplines

Great thinkers going back at least to Aristotle have always made clear that a good life consists of much more than just material possessions. Over time they have developed long lists of characteristics of good and fulfilling lives. For example, economist Manfred A. Max-Neef offers a list of nine items ranging from subsistence to freedom that satisfy human needs[17]. Many of these needs have a strong link to education and learning:

- Understanding: Curiosity, receptiveness and discipline allow us to investigate and analyze.
- Creation: Passion, imagination and determination allow us to invent and design.
- Freedom: Autonomy, self-esteem and passion allow us to choose and to run risks.
- Identity: A sense of belonging, consistency and assertiveness allows us to decide and commit ourselves.

Economist Amartya Sen and the philosopher Martha Nussbaum focus more on human capabilities ranging from bodily health and integrity to play and affiliation. Again, many have a strong link to education and learning, for example:[18]

- Practical reason: being able to form a conception of the good, and critically reflect about one's own life.
- Senses, imagination and thought: combine education, training and experience to work, produce and speak in a truly human way.
- Emotions: Being able to have attachments to things and people outside ourselves.

Political scientist Ronald Inglehart followed in the footsteps of psychologist Abraham Maslow (hierarchy of needs) to argue that human needs change over the course of development: Education and innovation fuel socioeconomic development, which triggers emancipative cultural changes with an emphasis on freedom, individual autonomy, choice, tolerance and trust. Finally, people ask for institutional changes towards more civic participation and direct democracy. The end result, according to this line of thought, is much higher complexity which needs to be handled with great skill.[19]

These theoretical approaches have much in common. And they make it difficult to think mechanically in terms of inputs, outputs and outcomes. All aspects of a good life come together, possibly with different weights and different specifications depending on time, personality and level of development. A skill that helped produce more of a wanted outcome in the past may no longer be the crucial input for producing more of that same outcome today. Likewise, a skill that was deemed important for one outcome in that past (e. g. making money) may now be crucial for a different but more relevant outcome (e. g. mental health). Relevant metrics and input-output ratios change over time. As a result, comparisons over time are likely to produce less relevant results. We will need to constantly update the way in which we assess the good life and the role of education therein.

Measuring Progress

In the past, a nation's success was usually measured using gross domestic product (GDP), the value of all goods and services for final use produced by the market economy in a certain period. In this perspective education was a way to accumulate "human capital", get a high paying job and boost national GDP or some concept as poorly defined as "competitiveness". Over the last few years, several initiatives have begun to seek better ways of measuring how well countries are doing. On the way, they are redefining the role of education as a mean to other ends.

The OECD is an important player, admitting that "Over the past 50 years, the OECD has developed a rich set of recommendations on policies that can best support economic growth. The task that we face today is to develop an equally rich menu of recommendations on policies to support societal progress: better policies for better lives."[20] Its new "Better Life Index" combines 21 indicators from 11 topics ranging from education and skills (school attainment and cognitive skills) to personal security and subjective wellbeing. Australia, Canada and Sweden are the best places to live according to this index. But the index cannot tell us whether life in a country has improved – there are no time series available.

The Frankfurt, Germany, based non-profit think tank "Center for Societal Progress" has published the second edition of its "Progress Index" in December 2011. The Progress Index combines four elements – income, life expectancy, years of education and the ecological footprint – for 22 countries and enables an assessment of where the lives of citizens have improved the most. In 2009, Norway, Sweden and Switzerland were the most advanced countries by this metric. Over the years 1999 to 2009, life improved the most in South Korea, Germany and Canada.

Education Can Boost Happiness – and Vice Versa

Over the past decade, empirical research especially in psychology and economics has identified a large number of factors that are related to peoples' perceptions of or expressed views on wellbeing or life satisfaction. Most of them are in line with the theoretical considerations – and in line with worldly wisdom. However, causalities are usually hard to identify: Often they seem to run from things that we used to consider as final output (such as happiness) to what we used to consider as inputs (education, work, health etc.). This shows again that many relevant themes come together in one big package and that causalities are hard to identify: happy people tend to be well educated, have lots of close friends, a high income, are in good health and trust others. But are they happy because they are educated? Do they have friends because they are happy? These questions are hard to answer and we may have to focus on the whole package.

Using the five items in Martin Seligman's wellbeing-theory we can provide a rough impression of some empirical results that all support the assumption that wellbeing and happiness can be actively pursued.[21] The list focuses on education and learning as a subset or component of wellbeing and happiness. It combines insights from psychologists (Lyubomirsky et al.) and economists (Dolan et al.):[22]

- **Positive emotion:** High self-esteem, an optimistic perspective on one's life situations (including the financial situation), avoiding social comparisons, gratitude and thoughtful self-reflection are all linked to high wellbeing.
- **Engagement:** Improving one's physical and mental health through meditation, physical activity or even gardening is beneficial, especially if it leads to a flow experience.
- **Relationships with other people:** Nurturing relationships with a life partner, family, friends or at work are all positively linked to wellbeing. Forgiveness and trust in others can help and can be practiced.
- **Meaning:** Belonging to and serving something that is bigger than the self provides meaning in life. The workplace is one significant source of such meaning since people feel needed, as are community involvement and volunteering.
- **Achievement and accomplishment:** Even if it is only for its own sake, the successful pursuit of life goals is good for us.

Money income also plays a role although recent research points to causality running from life satisfaction to income.

Using the Sen/Nussbaum capabilities approach, Anand and coauthors (2009) have shown with survey data from the UK that a large number of capabilities are closely linked empirically to subjective wellbeing. Many are also linked to a broad definition of education and learning:

- Practical reason, especially whether a person has an idea of a good life based on his own judgment and whether the person has a clear plan of how he would like his life to be.
- Emotions, especially whether a person is able to express feelings of love, grief, gratitude and anger.

Formal measures of education, as so often in empirical studies, did not have additional explanatory power in these simple regression models, where all explanatory variables are (wrongly) assumed to be independent of each other.

New Curricula are Being Developed

These theoretical insights and empirical results could give rise to new curricula in schools and universities, which would actually be in line with what parents all along want their children to experience there: happiness, confidence, meaning, fulfillment, kindness, being civilized etc. (Seligman 2011, p. 78). And they could give rise to a new way of thinking about contexts and places where learning takes place and where knowledge is being transmitted outside the classroom. In this new thinking, current schooling systems may no longer be the only or even second best approach to acquire the skills and knowledge we want.

In reality, schools are still institutions that mechanically get children ready for the workplace by teaching them math, literacy, conformity and discipline. But increasingly the focus is moving away from technical and material aspects.

The content and purpose of traditional schooling begins to shift in recognition of a changing context and changing priorities. So far, many courses are only for psychology students, but it seems that they are spreading to a wider audience. Three examples illustrate what is happening:

1. Led by Martin Seligman, the Penn Resiliency Program focuses on resilience, gratitude, strengths, meaning, flow, positive relationships, and positive emotion – with scientifically proven success. Most exercises in the curriculum are easy to implement. For example, students are asked to write down daily for a week the three good things that happened (positive journaling). Or they are asked to interview family members to develop a "family tree" of strengths. Or they are asked to write gratitude letters to their parents. Schools in the USA and Australia are using this setting already.

2. A school in Heidelberg, Germany, introduced a two-year course "happiness" in 2007 based on insights from positive psychology and other disciplines. It supports children to reach a state of physical, mental and social well-being, by identifying aspirations and by helping them to better cope with their environment – in line with a broad definition of health. The courses success has been shown scientifically. Ten modules deal for example with how to set goals in life, how to treat oneself and others with respect, how to express oneself by using both body and voice, how to handle outside influences such as advertising, and how to interact in teams.

3. The three-week online kindness class was created by Andy Smallman following a course he created for the Puget Sound Community School in the USA. It first asks people to do something kind for themselves, then for a good friend and then for a stranger. The focus is on activities and mindful reflection. There is also a follow-up module on anonymous kindness.

Learning and Education as an Ingredient to Local Wellbeing

When people are asked to think about an attractive future for themselves and their community, learning and education is one of several important aspects. Other elements of a good society that are usually considered are health, the natural environment, high quality community, safety, traffic, housing, good governance, the arts and of course the economy. Here again, it is difficult to determine weights and keep track of the many linkages between the different dimensions.

Projects that ask individuals about their perspective about the good life are often done at the local or regional level. Prominent examples include Tasmania Together, the Santa Cruz County Community Assessment Project, the Jacksonville Community Indicators and the Vancouver Vital Signs. Each project uses more than 100 indicators to track whether life is getting better and to determine areas of priority action.

Within the education-learning nexus, quantitative output measures such as dropout and graduation rates, degrees awarded and literacy rates dominate. Quality measures are spreading: test scores on an academic performance index (Santa Cruz) or the Florida comprehensive assessment test (Jacksonville).

Some projects go deeper: Jacksonville and Vancouver ask residents about their satisfaction with public education, Santa Cruz measures the number of items circulated by the public library, Vancouver captures the number of people who read a newspaper as well as access to arts and music classes. Other variables in these indicator projects have not yet been extended to cover the dimensions of wellbeing as listed above. At the national level, the Canadian Index of Wellbeing already includes a composite index of five domains that reflect social and emotional competences of children in middle childhood, in line with

research from psychology: empathy; prosocial behavior; friends/social relationships; self-esteem and (with a negative sign) bullying.

It is a long way, before indicator projects incorporate most of the insights from positive psychology and happiness economics and the theoretical insights highlighted above. We are in the midst of an ongoing process, where individuals and societies redefine what is important and valuable to them. This has consequences for the variables we define and measure to capture wellbeing. Learning and the systems that enhance learning will be an ingredient in this societal re-think process and it will be affected by it in multiple ways.

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Riel Miller's work has concentrated on how to use the future to assess and direct the potential for socio-economic transformation in the private and public sectors. He started his career at the OECD Economics Department in 1982 and has worked as a Senior Manager in the Ontario Civil Service (Ministries of Finance; Universities; Industry) and for the International Futures Programme at the OECD for a decade. In 2005 Riel founded a specialized global consultancy, xperidox futures consulting, that helps clients in the public and private sectors to use the future strategically. Riel has a PhD in Economics, is widely published, and teaches and speaks around the world. For a full list of publications, employment and speaking engagements see: www.rielmiller.com

Ilkka Tuomi is the Founder and CEO of Oy Meaning Processing Ltd. He has written five books, chapters in 23 books, over 40 scientific articles, and numerous scientific reports. His texts have been used as background material for the development of national, regional, and European research strategies, the World Summit on Information Society, European Commission communications, and the revision of the eEurope strategy. Mr Tuomi has been a member of the European Commission's Socio-Economic Expert Group on Information Society, as well as an expert member in several Commission's working groups, ranging from Internet security to digital identity, technology-enabled learning, open source innovation models and policies, computing futures, scientific e-Infrastructures, regional innovation systems, and future mobile technologies. He has been an executive board member of the Finnish Information Society Forum, and twice nominated member of the Scientific Council of the Finnish Innovation Fund (SITRA).
Before his current position, Mr Tuomi was with the European Commission's Joint Research Centre, Institute for Prospective Technological Studies. From 1987 to 2001 he worked at Nokia Research Center, Finland, most recently as Principal Scientist, Information Society and Knowledge Management.

Endnotes - Paper 2, Sections 1, 2 and 3

1 United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics and World Bank Database.

2 World Bank Policy Research Working Paper, "Development Goals: History, Prospects and Costs," by Shantayanan Devarajan, Margaret J. Miller, and Eric V. Swanson

3 Stiglitz, Joeseph E., Amartya Sen, Jean-Paul Fitoussi, Mis-measuring Our Lives: Why GDP does not add up, The New Press, 2010.

4 Syverson, Chad, "What Determines Productivity", Journal of Economic Literature, 2011, 49:2, 326-365; http:www.aeaweb.org/articles.php?doi=10.1257/jel.49.2.326

5 For the purposes of this paper the term "well-being" denotes the current state of health/happiness of a person and/or a group of people – well-being is a flow, it is experienced and is related to activity in the present; wealth denotes a stock, something that exists in the present but was accumulated/created in the past and has the potential (although not the certainty) of being useful in the future. See Section 3 by Stefan Bergheim for a more fully developed discussion of well-being.

6 Lundvall, Bengt-Åke, Why the New Economy is a Learning Economy, DRUID – Danish Research Unit for Industrial Dynamics, Working Paper No 04-01, ISBN 87-7873-151-8

7 Wenger, Etienne, (1999), Communities of Practice: Learning, Meaning and Identity, Cambridge University Press

8 It is important to recognize that the term productivity and even learning already rest on a set of framing assumptions. The term productivity is firmly rooted in the input-process-output perspective that suffers from numerous flaws, such as a tendency to linearity and compartmentalization. The term learning is usually biased towards volitional and conscious acquisition of knowledge. We recognize these limitations and will attempt to be vigilant in recognition of the boundaries imposed by such assumptions.

9 There are several descriptions of Dewey's learning cycle in the existing literature. Here we rely on Miettinen (2000), who also carefully reviews the problems in many popular interpretations of Dewey's theory.

10 This, indeed, was one of the main insights of Lev Vygotsky (e.g., Kozulin 1990; Vygotsky 1986), whose cultural-historical theory has become a foundation for much of recent research on learning.

11 According to Constant (1980, 15), a presumptive anomaly occurs in technology, "not when the conventional system fails in any absolute or objective sense, but when assumptions derived from science indicate that under some future conditions the conventional system will fail (or function badly) or that a radically different system will do a much better job." Presumptive opportunities have been discussed in Tuomi (2002, 100).

12 Although it is possible to estimate, for example, the statistical impact of educational achievement on income levels, the links between income and educational achievement, of course, are very complex and depend on very many idiosyncratic factors (Miller, 2008). The value of learning is rarely measured on the market. For example, one would need to be rather heavily constrained by economic theory to claim that the value of literacy is its impact on income.

13 There is now extensive and rapidly growing literature on the capability-based approach to economic development. For recent overviews, see Sen (2009) and Nussbaum (2011).

14 Here we rely on the analysis of Tuomi (1999, 392–5).

15 According to several recent studies, the main source of economic growth has in many countries been productivity improvements in the computing industry. These productivity improvements, however, result from the fact that output volume has been adjusted to take into account technical improvements. A major factor underlying economic growth in the US, for example, has been the fact that there are now more transistors on a microprocessor chip than before. Whether this actually should be interpreted as true output volume growth is highly questionable, on both theoretical and empirical grounds (Tuomi 2004).

Endnotes - Paper 2, Sections 1, 2 and 3

16 Recent macro-economic growth and productivity studies are often mis-interpreted in this regard. It is technically possible to split components of observed output growth among various sources, including labour working hours and investments into, for example, human capital, ICT hardware and software, production plant, the intensity or regulation, and other factors. Although such calculations can reveal how the observed growth can be accounted for by various types of expenditure, investment and policy under equilibrium conditions, such associations do not have any underlying causal model. Although high investments in human capital, for example, tend to be associated with high output growth at the national level, it is not possible to use this to claim that high investments in human capital will lead to high growth. For such causal claims we need causal models.

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