March 2005

Education Policy Analysis Archives 13/20

Arizona State University

University of South Florida

EDUCATION POLICY ANALYSIS ARCHIVES

A peer-reviewed scholarly journal
Editor: Sherman Dorn
College of Education
University of South Florida

Volume 13 Number 20 **March 10, 2005** **ISSN 1068-2341**

Workforce Quality Goals and the Implications for Education: The Oregon Experience

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Citation: Sivers-Boyce, N., Hibbard, T. & Gray, J. (2005 March 10). Workforce quality goals and the implications for education: The Oregon Experience. *Education Policy Analysis Archives, 13*(20). Retrieved [date] from http://epaa.asu.edu/epaa/v13n20/.

Abstract
We review a plan that attracted the attention of public sector planners everywhere, Oregon's 1989 *Oregon Shines: An Economic Strategy for the Pacific Century*. In particular, we focus on Oregon's aspirations for world-class workforce quality; a status that the state's planners argued would contribute to a host of other outcomes that foster citizen well-being. The broader purpose of the paper is to emphasize the importance of timing. Planners must remain mindful of the long timeframe required for educational improvements to directly benefit the economy. We begin by reviewing the arguments that planners offered for the centrality of workforce quality. Second, we briefly review a few indicators of the state's commitment to achieving a world-class workforce and the consequences of this commitment to date. Third, we show that failure to dynamically model the linkages between actions and outcomes led to adoption of a workforce goal that was unattainable even if commitment had been Herculean.

Finally, we consider other planning targets that might be improved by understanding why Oregon's workforce quality goals were unachievable.

Introduction

Reduced to its essence, planning is deciding where we want to be and what we need to do to get there. Most of us embrace planning conceptually while understanding that plans are seldom carried out to perfection. Reasons for planning failures abound. Inadequate commitment to implementation and an imperfect understanding of how actions and outcomes are connected are only two of the more obvious reasons why "the best laid plans of mice and men sometimes go awry."

This article reviews a plan that attracted the attention of public sector planners everywhere, Oregon's 1989 *Oregon Shines: An Economic Strategy for the Pacific Century.* In particular, we focus on Oregon's aspirations for world-class workforce quality; a status that the state's planners argued would contribute to a host of other outcomes that foster citizen well-being. The broader purpose of the paper is to emphasize the importance of timing. Planners must remain mindful of the long timeframe required for educational improvements to directly benefit the economy. We begin by reviewing the arguments that planners offered for the centrality of workforce quality. Second, we briefly review a few indicators of the state's commitment to achieving a world-class workforce and the consequences of this commitment to date. Third, we show that failure to dynamically model the linkages between actions and outcomes led to adoption of a workforce goal that was unattainable even if commitment had been Herculean. Finally, we consider other planning targets that might be improved by understanding why Oregon's workforce quality goals were destined to "go awry."

Background

In his *Oregon Shines* introduction, then-Governor Neil Goldschmidt wrote, "(w)e are clear about what we want: well-paying, productive jobs for Oregonians, providing an economic base that enriches all aspects of Oregon life." He explicitly recognized that success would "…require hard work over a sustained period of time." The payoff for a job well-done would be, "…a prosperous economy amid a rewarding quality of life sustained by sound public services and a healthy natural environment." On the other hand, Goldschmidt warned, "(i)f we ignore the work we need to do and the investments we need to make, Oregon could easily drift into the next century with a low paid workforce unprepared for new technology and international competition, with deteriorating infrastructure and public services, and with the congestion and gridlock that now plague other regions."

Goldschmidt's introductory remarks made it clear that the state's workforce would be a key factor in whether or not the state would enjoy the prosperous future he envisioned. The very large number of citizens who participated both in developing the *Shines* vision and charting the arduous course required for its realization, and those who fashioned citizen views into the strategic plan itself underscored the governor's remarks by listing "a superior workforce" as one of three key strategic initiatives that the state should pursue. This initiative, calling for

investing "…in Oregonians to build a workforce that is measurably the most competent in America by the year 2000, and equal to any in the world by 2010," is surely the most memorable passage in *Oregon Shines.* The initiative continued: "…we must challenge and enlist the state's social service and education institutions to serve competitive economic objectives. We must nurture the development of our young children, prepare our young adults to enter a skilled and globally-oriented workforce, and provide continuing education to our workers and managers to stay abreast of changing markets and technologies." Again, it is clear the planners understood that citizens would need to make some costly public and private choices to reach the lofty goals set forth in the state's strategic plan.

Underlying Analysis in *Oregon Shines*

Why did the governor and his planners highlight workforce quality in their strategic plan? Perhaps the single most important reason is revealed just four pages into *Oregon Shines*: "The economic distress experienced this decade (1980s) in Oregon has been painful for both individuals and communities. A per capita income that exceeded the national average in the late 1970s was hit so hard that it still languishes 8 percent below the national average" (p. I-4). A marked improvement in workforce quality would surely move us forward toward those "…well-paying, productive jobs…."

Oregon Shines attributes much of the swoon in the 1980s to developments in its forest products industry. Technological change in harvesting and processing, reductions in timber harvest levels, an increase in log exports, and high interest rates that reduced the demand for new housing all played important roles in cutting the demand for timber-related labor which, in turn, hampered Oregon's economic growth and prevented income levels from keeping pace with the rest of the country. Depressed incomes translated into depressed tax receipts that made it increasingly difficult for the public sector to provide services for those in need and an infrastructure package that could both prevent businesses from leaving for better circumstances elsewhere and attract footloose enterprises to the state. Finally, "…economic frustrations contribute to higher levels of family instability, placing children at higher risk—diminishing their development as healthy adults and productive citizens" (p. I-5). The authors of *Oregon Shines* were describing a *circle of austerity*.

But planning efforts were not simply aimed at halting and reversing a downward spiral that, in fact, was abating by 1988-89. It was largely awareness of changes in the external economic environment and extrapolation of these trends that called for a careful assessment of how Oregon was positioned and what it might need to do to truly prosper in the evolving economy.

What were these changes that state planners believed warranted the attention? *Oregon Shines* uses terms such as technological revolution, information economy, and new economy to describe the changes that citizens needed to plan for in the next couple of decades. It mentions, "computers, telecommunications, materials sciences, genetic engineering, and robotics" (p. I-11) as fields within which the technological revolution was, and is, taking place. In the view of the planners, these developments influence both the composition of output, and the methods that are used in producing goods and services. *Oregon Shines* makes a case that developing these new technologies and understanding how to apply them is critical to the prosperity of any region's citizenry. It follows that "(a) region whose workforce

has strong basic skills and specialized training will enjoy a competitive advantage and command higher wages" (p. I-12).

Oregon Shines also observed that both the trend toward freer international trade and the exceptionally rapid economic growth of nations and regions on the Pacific Rim at that time provided strong incentives to move as quickly as possible in adopting emerging technologies. First, global competition would spur local firms to produce new products and to cut costs, and second, doing so would enable Oregonians to prosper as its businesses exported more to economically strong neighboring states and countries.

Workforce Quality in the Late 1980s

Having identified some of the key trends that were transforming the economic environment in the late 1980s, the authors of *Oregon Shines* turned to a consideration of how well the state was positioned to prosper in the emerging "new economy". In particular, *Oregon Shines* assessed the state's human capital.

The message was mixed. The good news was "Oregon's labor force is (1989) relatively well educated." The bad news was "…the United States is (1989) behind other nations in educational attainment in several key areas, including math and science, literacy, and problem solving skills" (II-21). Especially disturbing was the *Oregon Shines* comment that "…most (young adults in the United States) can't read a bus schedule, compute a restaurant bill, or describe the main points of a newspaper article" (II-21).

The state's late 1980s status as "relatively well educated" in a nation that was trailing many developed and developing countries hardly warranted complacency. Accordingly, *Oregon Shines* included extensive analysis and numerous recommendations aimed at improving the state's workforce quality. Policy proposals concentrated on k-12 and higher education, but they included recommendations for pre-school programs beginning with pre-natal care, and post-school training as well. Clearly, the governor and his planners supported their call for workforce superiority with detailed recommendations for attaining it.

An improvement in workforce quality could discourage enterprises from leaving, attract other enterprises, and boost incomes. In addition, the authors of *Oregon Shines* expected a cascading of other desirable outcomes to accompany these obvious benefits of enhanced workforce quality. These planners argued that workforce quality was one component in a *circle of prosperity* and, as such, could yield a host of other benefits. This circle of prosperity would be a mirror image of the circle of austerity that Oregon endured in those dismal 1980s. Workforce quality accompanied by "a clean environment and responsive public services" would "attract and provide a base for diverse, value-adding industries…and well paying jobs" which reduce "poverty and crimes" and "generate revenues for: quality public services, and public facilities" which, in turn, lead to improvements in the environment, workforce, and public services. The circle is complete. According to this logic, improving workforce quality could trigger the "…prosperous economy amid a rewarding quality of life sustained by sound public services and a healthy natural environment" that the governor described in his visionary introduction to *Oregon Shines.* It is clear that much was expected of workforce quality.

Linking *Oregon Shines* to Analyses of the "New Economy"

The goals and strategies reflected in *Oregon Shines* are remarkably consistent with the arguments presented by former Labor Secretary, Robert Reich. *Oregon Shines* and Reich's 1991 book, *The Work of Nations*, both emphasize linkages between workforce quality and living standards. Reich begins his book in the following way:

> We are living through a transformation that will rearrange the politics and economics of the coming century. There will be no *national* products or technology, no national corporations, no national industries…. Each nation's primary political task will be to cope with the centrifugal forces of the global economy which tear at the ties binding citizens together – bestowing ever-greater wealth on the most skilled and insightful, while consigning the less skilled to a declining standard of living [Reich, p. 3].

Reich's warning and call to action are even more pressing for states, and the emphasis on workforce quality in *Oregon Shines* can be usefully comprehended as part of a response to these transformations.

In Reich's view, new production, transportation and communication technologies are transforming place-bound, pyramid-shaped firms into fluid webs of economic activity with increasingly porous boundaries. This transformation presents challenges and opportunities for states to develop the infrastructure and assets that will retain and attract business in the emerging economy. In particular, this "new economy" will value and seek out workforces with more abstract skills such as "problem-solving, problem-identifying and strategic-brokering" [Reich, p. 177]. Oregon's central challenge in developing workforce quality was to "increase the potential value of what its citizens can add to the global economy by enhancing their skills and capacities and by improving their means of linking those skills and capacities to the world market" [Reich, p. 8].

Assessment

A chief strength in *Oregon Shines* is its emphasis on translating lofty goals into *measurable* outcomes. Any brief review of the state's progress over the last decade will necessarily omit volumes of pertinent information, but education and training should be core features in such a review. Workforce quality is an instrument for achieving favorable economic outcomes, rather than end-in-itself, so economic outcomes should also be featured. Our few *measures* of progress reflect three elements in a simple underlying logic.

First, if new technologies increase the mobility of capital, then state rankings become an important metric. Frank and Cook [1995] argue that one of the distinctive features of the new economy is that *relative* performance or productivity may be more important than *absolute* performance in determining economic outcomes. This explicit emphasis on rank echoes Reich's concern that the emerging economy may bestow "ever greater wealth on the most skilled and insightful, while consigning the less skilled to a declining standard of living" [Reich, p. 3]. New technologies and increasing mobility of capital tend to focus attention on relative ranking rather than absolute levels of achievement, so our review of Oregon's progress focuses on state rankings.

Second, formal education is the primary policy option for influencing the problem-solving skills that are highly valued in the emerging economy. Therefore, we emphasize selected measures of educational "inputs" and "outcomes" in assessing performance over the last decade. In particular, we examine Oregon's state ranking in certain measures of education spending and performance on national exams.

Finally, workforce quality is pursued primarily as a means to economic success so we explore Oregon's state ranking in selected measures of economic performance. Rising standards of living are one of the key linkages in the circle of prosperity, and Oregon's ranking in economic performance is partially attributable to its performance in developing workforce quality. In any event, achieving high levels of workforce quality without the attendant payoffs in terms of standards of living would be a hollow accomplishment.

Selected Measures of Education Spending

Using "inputs" to usefully measure educational quality clearly requires information on how productively inputs are being utilized. Nonetheless, it is worthwhile to review indicators of Oregon's rank in the amount of resources devoted to education. We present information on three different measures at discrete points over the last decade: 1) per-pupil expenditure in elementary/secondary education, 2) per-capita state and local government expenditures for education, and 3) expenditures for education as a percent of all state and local government expenditures.

These metrics shed light on different features of the state's commitment to education spending. Per pupil expenditures in elementary/secondary education reflects ranking in the amount of resources available for each student in grades k-12. Like per-capita expenditures for education, this measure will be strongly influenced by levels of economic prosperity between states. Levels of economic prosperity have less influence on measures of expenditures for education as a percent of all state and local government expenditures, and these measures also reveal something about the *de facto* priority attached to education spending.

The slight decline in the state's rank in per-pupil expenditures between 1996 and 2000 (Table 1) is probably not as significant as the fact that Oregon is clearly not a national leader.

Table 1
Education Expenditures

Measure of Expenditure	**Rank in 1996**	**Rank in 2000**
Per-Pupil Expenditure on Elementary and Secondary Education	16	19
	Rank in 1993	**Rank in 1999**
Per-Capita State and Local Government Exp. for Education	13	17
Exp. for Education as a Percent of all State and Local Government Exp.	25	36

Source: Morgan Quitno Press, *State Rankings: A Statistical View of the 50 United States*, various years.

Per-capita spending on education in 1993 and 1999 also seems unexceptional and exhibits the same slippage in the 1990s. The data in Table 1 on education expenditures as a percent of all state and local government expenditures is more striking. This data would be less significant if Oregon were among the nation's leaders in education spending, but modest national rankings in per-pupil and per-capita spending focuses attention on the state's allocation of resources between competing priorities. Oregon does not compare well with other states in its commitment to education spending. Only 14 states devoted a smaller share of expenditures to education in 1999.

Selected Measures of Education Outcomes

Reich's analysis identifies problem-solving, problem-identification and abstract reasoning skills as essential to workforce quality in the emerging economy. Such an analysis focuses attention on the success of schools in imparting these abilities. Critical thinking and reasoning skills are notoriously difficult to quantify, but the admirable emphasis that *Oregon Shines* placed on measurable outcomes almost necessarily draws us to results on standardized exams. The *National Assessment of Educational Progress* (NAEP) conducts representative assessments in participating states and is often referred to as the "nation's report card." Oregon's rankings in Mathematics and Science are generally unremarkable, but rankings improve at higher grades.

Table 2
Oregon NAEP Ranking

Exam	Grade	Rank in 2000
Math	4th	20th (of 40)
Science	4th	22nd (of 39)
Math	8th	11th (of 39)
Science	8th	15th (of 39)

Selected Indicators of Economic Performance

Efforts to raise standards of living motivate emphasis on workforce quality. Rising incomes and declining poverty rates relative to the rest of the nation would be consistent with success in enhancing workforce quality. Table 3 shows Oregon's rank in poverty rates and average annual pay, which shed some light on the state's relative success in enhancing workforce quality and in translating these qualities into rising living standards. Of course, many factors other than workforce quality will influence these measures of economic performance. Still, such quantitative results are one source of evidence for judging progress.

Table 3
Economic Outcomes

Measure of Economic Performance	Rank in 1990	Rank in 1995	Rank in 2000
Poverty Rate	15th	21st	35th
Average Annual Pay	26th	23rd	19th

Source: Morgan Quitno Press, *State Rankings: A Statistical View of the 50 United States*, various years.

The results in Table 3 are mixed. Average annual pay of covered workers rose relative to other states over the ten-year period in question. This relative improvement is balanced by significant deterioration in the state's poverty-rate ranking (where 1st is the lowest poverty rate).

Summary

Our review of these few measures do *not* reveal significant progress in relative education performance and economic outcomes in Oregon during the 1990s. Moreover, the evidence suggests that one possible explanation for these indifferent results is that the state failed to support its ambitious goals with sufficient investment. This conclusion begs the question: Would significantly different results have been observed if appropriate investments had been made? We turn our attention to this question.

The Importance of Timing

Higher levels of spending on formal education could not have accomplished Oregon's goals of building the most competent workforce in America by the year 2000 because of a fundamental inconsistency between the timeframe and mechanism chosen to meet this goal. We begin by making several simplifying assumptions to model the process of improving workforce quality through investments in education. We then explore the significance of each assumption.

- All new workers enter the workforce with a high school education obtained in state,
- The state's workforce is the same size year in and year out;
- Since the drafting of *Oregon Shines*, the state has made sufficient (annual) investments in education to revolutionize its k-12 system and produce students who have the skills to be the best workforce in the nation;
- These are the only investments the state has made to pursue its workforce agenda.

If all these assumptions were true, where would we be today? *The quality of the workforce would have changed only slightly for two reasons*. First, only a small fraction of the workforce will be replaced in a given year so the new skills will enter the workforce slowly, over an extended period of time. Second, exacerbating the problem of slow turnover is the observation that workers who enter the workforce initially will have been educated only partially under the new system. Presumably, students educated under the new system will develop a different set of skills than students educated under the old system (or educated in other places). However, students who are only partially educated under the new system will not develop the entire new skill set. Thus, the first "full strength" worker does not even enter the system until twelve years after the change.

If we make slightly stronger assumptions, it is possible to quantify these insights in an illustrative way.[1] Figure 1 shows the percentage of new skills (the product of the new education system) and other skills in the workforce over time, assuming a 2.2%[2] annual

[1] See the appendix for detailed modeling equations.

[2] The 2.2% turnover rate is derived by assuming that new workers enter the force at age 18 and retire at age 62. So, in any given year there are 44 worker cohorts (by age) of equal size, and one of those cohorts will retire. Thus, 1/44 ~ 2.13% of the workforce is replaced each year. The results are sensitive to this

worker turnover rate and assuming that a student educated for x years under the new system will have $x/12$ of the new skills and $(12\text{-}x)/12$ of other skills.[3] Note that under these assumptions only 12.1% of the skill base has been converted by the eleventh year after the program of investment begins. Further, note that it takes twenty-nine years to convert half of the workforce, and it is fully fifty-seven years before the entire workforce is converted!

This simple model makes it clear that relying exclusively on investments in primary and secondary education is unlikely to achieve the stated goals within the targeted timeframe. It takes a long time to transform the entire workforce because only a small proportion is replaced each year. This is not to say that such investments are unimportant. Investment in early education is undoubtedly essentially for developing a *stably* improved workforce over time. However, it will not produce this workforce transformation quickly, and official planning and rhetoric should reflect this reality.

Is this insight driven by the assumptions that simplified our analysis? Let us relax each in turn and consider the effect on the timing of workforce turnover.

- Suppose that some workers entering the workforce were not the product of state high schools (labor in-migration). In this case, it would take even longer for the results of the new educational system to be reflected in the labor pool. Further, it would *never* be the case that the entire pool is composed of workers educated under the new system.

- Suppose that the state's workforce were growing rather than of a constant size. If this were the case, then the rate at which new workers enter the workforce would exceed the rate at which workers retire. The salient question is: Where do the new workers come from? If they come from outside the state, then the comments above apply. If they come from state high schools, then the new skills will enter the workforce more quickly than indicated above. However, this is only a marginal change; transformation will still occur slowly.

- Suppose the state were to invest in other programs, such as vocational training or post-secondary programs. If this were the case, the effect would depend on the particular program. Investing in post-secondary programs would perhaps produce an even more greatly improved skill set but at the cost of making the transformation slower since at least some students would choose to delay their entry into the workforce. However, investing in vocational training could speed up the introduction of new skills into the workforce considerably. By training current workers, the transformation of the workforce is no longer constrained by the rate at which new workers are entering.

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assumption. In general, the higher the turnover rate, the faster the conversion will be. Complete conversion occurs in 1/(turnover rate) + 11 years. 2.2% is a reasonable starting point.

[3] This assumption is admittedly arbitrary, but it is fairly innocuous. A different assumption would yield slightly different results, particularly in the first 12 years. However, the time it takes to completely change the workforce is independent of the assumption we make here!

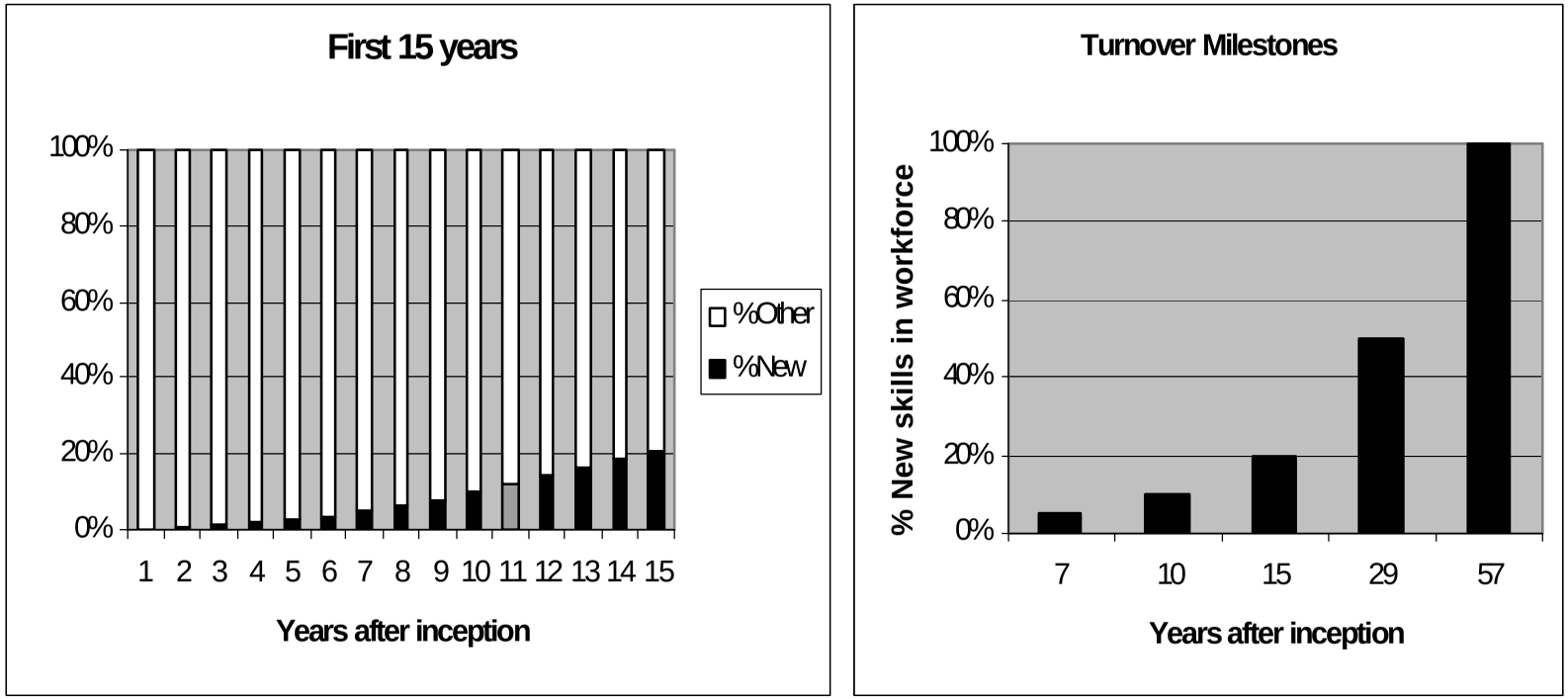

Figure 1. Changes in the composition of the workforce over time.

This basic insight is very robust. A strategy that relies exclusively on investment in education, and therefore on new workers, to introduce new skills will improve the workforce steadily but slowly. If rapid improvement is sought, then other mechanisms for change (e.g. workforce training) should be investigated.

Policy Implications

Our analysis of Oregon's efforts to achieve stated workforce quality goals for 2000 and 2010 has four implications for policymakers. First, increase outlays on education. An obvious strategy for coping with the problems of improving workforce quality that we have been addressing here is to accelerate and multiply outlays for education. This strategy is obvious, but it is not likely to enable the state to reach its 2010 workforce quality goal. The reasons, as we have explained above, is that this approach will only affect the workforce quality for the small number of graduating students who will be entering the labor force over the next half-dozen years or so. It will affect the quality of their schooling for only those remaining years prior to graduation. Most importantly, it would impact the great majority of the labor force only through interactions with better-educated colleagues on the job.

Second, allow more time for achieving workforce goals. The more time, the greater will be the number of workers who have benefited from an enhanced educational program. Also, more of these workers will have the full k-12 program improvement.

Third, training can have more immediate effects on the current workforce. A major problem that we have identified in workforce quality enhancement is the lengthy time required for the labor force to turn over. One way of addressing this problem is to put more effort into training the existing workforce. Few would advocate wholesale substitution of improved training for educational improvement, but some marginal shifts of resources might allow the state to meet its workforce quality goals earlier rather than later.

Finally, workforce outcomes affect other *circle of prosperity* measures. To the extent that the state fails to reach its workforce quality goals on the original timetable, the citizenry should not be surprised to see that other desirable outcomes become more difficult to attain. Modest workforce quality may cause firms to leave and deter others from entering. Incomes could decline or advance slowly and tax receipts could follow the same pattern. Indeed, Oregon has experienced such circumstances in recent years. These outcomes make it difficult to make infrastructure improvements, protect its environment, and provide for those citizens who are at risk. Oregon might have mitigated these outcomes by following through on the *Oregon Shines* recommendations, but achieving the timeframe outlined was never realistic.

Conclusion

Unveiled in 1989, *Oregon Shines* compellingly argued that superior workforce quality could be a springboard for "enrich(ing) all aspects of Oregon life." For some reason, though, Oregonians have neither made the sacrifices that were necessary, nor have they realized the lofty goal of "build(ing) a workforce that is measurably the most competent in America by

the year 2000…." The rankings that we presented in Section 3 seem to reflect inadequate commitment and mediocre workforce quality achievements.

On closer inspection, though, Oregonians never had a realistic chance of rapidly improving their workforce quality, especially by relying mainly on changes in k-12 education. Even a simple model of how education affects only new entrants to the labor force reveals how difficult it is to achieve rapid improvement in the total workforce. And, in general, replacing simplifying assumptions with more realistic ones turns out to strengthen our contention that *Oregon Shines* set the workforce quality bar at an unattainable height. If planners aim to lay plans that might not go awry, they would be well-advised to build models that reveal how policies affect outcomes quantitatively over time.

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Appendix: Modeling Details

Rather than tracking workers, we will keep track of the skill base of the workforce. This is a useful device since, for the first eleven years after the investment, new workers have not had the full twelve years of education under the new system.

Let: t = # of years after the program of investment begins

x_t = % of new skills in the workforce in year t

y_t = % of other skills in the workforce in year t

Since all skills in the workforce at a given time must be either "new" or "other" it follows that:

$$y_t = 100\% - x_t$$

Let r be the annual workforce turnover rate. Based on the simplifying assumptions in section 4:

$$x_t(r) = \begin{cases} x_{t-1} + \frac{t}{12} r & 1 \le t \le 11 \\ x_{t-1} + r & 12 \le t \le \left\lfloor \frac{100}{r} \right\rfloor \\ x_{t-1} + r - z_1(t,r) - z_2(t,r) & \left\lceil \frac{100}{r} \right\rceil \le t \le \left\lceil \frac{100}{r} \right\rceil + 11 \\ 100\% & \left\lceil \frac{100}{r} \right\rceil + 11 < t \end{cases}$$

where

$$z_1(t,r) = \frac{\left(t - \left\lfloor \frac{100}{r} \right\rfloor\right)}{12} r \left(1 - \frac{100}{r} + \left\lfloor \frac{100}{r} \right\rfloor\right)$$

and

$$z_2(t,r) = \frac{\left(t - \left\lceil \frac{100}{r} \right\rceil\right)}{12} r \left(\frac{100}{r} + \left\lfloor \frac{100}{r} \right\rfloor\right).$$

This model is much less complicated than it looks. It is driven by two questions. Who is entering the workforce at time t? Who is retiring at time t?

The first line represents the fact that during the first twelve years workers who enter the workforce have not had a complete education under the new system. Thus, they add only

$\frac{t}{12}$ of the news skills of a completely educated worker. Workers retiring at this time have no education under the new system. So none of the new skills are lost when they leave.

The second line represents the fact that from the twelfth year through the year $\left\lfloor \frac{100}{r} \right\rfloor$ all workers who enter the workforce have a complete education under the new system, while retiring workers have no education under the new system.

The third line indicates that between the years $\left\lceil \frac{100}{r} \right\rceil$ and $\left\lceil \frac{100}{\mathrm{r}} \right\rceil + 11$ all workers who enter the system are completely educated, but the workers leaving the system are partially educated under the new system. Depending on the turnover rate, partially educated workers with two different levels of education may be retired. The new skills lost in this way are indicated by the functions $z_1(t,r)$ and $z_2(t,r)$.

The fourth line indicates that after the year $\left\lceil \frac{100}{r} \right\rceil + 11$ the conversion of the workforce is complete. From this point forward, all workers entering the workforce are fully educated under the new system as are all retiring workers. Thus, the workforce remains entirely comprised of workers with all the new skills.

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