Appendix B Measuring Effectiveness Within a School System

Consider a local vocational high school. Efficiency is necessary for any well-run school system, but in the final analysis, education must also be judged on its quality, a proxy measure of which can be considered to be the school's effectiveness in achieving its Strategic Objectives.

Using the terminology of the Methodology section of the web site, we should first define the Outcomes the school system wishes to achieve, and they should be in support of the school's Strategic Objectives. In the case of a vocational high school, the Strategic Objectives could perhaps be twofold:

1. Prepare the graduates to be contributing citizens, as evidenced by their successful entry into the workforce.

2. Prepare the graduates for entry into higher education.

Each of these Strategic Objectives should have its own set of supporting Outcomes and quantifiable Outcome Indicators. For the first objective, a feasible Outcome Indicator could be the time it takes to get a non-minimum wage job, once the graduate initiates a serious search. (This would require either feedback from the graduates or, being a vocational school, perhaps the school would have a job placement office that would be able to gather the information directly.) For the second objective, two feasible Outcome Indicators could be the Verbal and Math SAT scores.

For both objectives, the task is to determine what the relationship is between the school Outputs (aggregated over the four years the student attended the high school) and the quantifiable Outcomes. External Factors that may influence the Outcomes, such as IQ (or some other standardized test result) and, in the case of the first strategic objective, the state of the economy, should also be considered. If the data is available or the cost to collect the data is not prohibitive, statistical techniques exist to perform such an analysis

However, before attempting to measure effectiveness, what exactly are the school's Outputs and what are the Activities that result in those Outputs?

A High School experience is not limited to classroom education alone, but there is no question that the dominant experiences are classroom related. Therefore, instructional-hours could be considered to be the dominant Activity engaged in by the school, and those hours can be categorized into the various subjects that are taught. Since the Output should be the direct result of the Activity, student-hours by subject taught would be appropriate Output descriptors. As indicated previously, the quality of those student-hours will be assessed by how well the school is meeting its objectives.

The data to track aggregate instructional-hours by subject taught and the resultant student-hour exposure to those subjects can be generated by the plan of the school year if the plan is a very close approximation to reality, but if class cancellations and/or student absenteeism are frequent, it may be necessary to adjust for those deviations from the plan. Assuming a vocational school with a student body of 300, Table B-1 reflects a hypothetical set of results for one year.

	Activity	Output	
Department	Aggregate # Instructional Hours	Aggregate # Student Instructional Hrs	Instructional Hrs/Student
Math	2,880	72,000	240
Science	2,520	63,000	210
English	2,880	72,000	240
Government/History	1,080	27,000	90
Vocational Training	1,440	36,000	120
Total	10,800	270,000	900

Table B-1 Activities and Outputs of a Vocational High School for a Single Year

The relationship between Outputs and Activities could be considered to be the operational efficiency of the organization. Applying that concept to Table B-1 allows us to determine the operational efficiency of the school. Using the fictional data shown, the average operational efficiency is seen to be 25 student hours per instructional hour (270,000/10,800), which is simply the average student/teacher ratio.

In addition to the Activity and Output data, if cost information is available for the various academic departments, other very useful efficiency indicators could easily be developed, such as the cost per instructional hour by department and the cost per student hour by department. The trends of such cost efficiency indicators over time can prove very helpful in establishing budgets and in detecting anomalies that require further investigation.

Returning to the challenge of measuring effectiveness, consider the more difficult Strategic Objective of the two, that which relates to preparing the graduates to enter the adult workforce, and assume that its corresponding Outcome Indicator was determined to be the average time it takes for a graduate to obtain a non-minimum wage job from the time he or she starts looking in earnest. Suppose further that over a 15 year period, the school had gathered the data in Table B-2, and was interested in whether there was correlation between the amount of time spent on certain courses during the four year period and the difficulty in obtaining meaningful employment after graduation. Each year in Table B-2 represents the average per student data associated with the graduating class of that year. Note that two External Factors are considered, the unemployment rate at the time of graduation and the average IQ of the graduates based on standardized testing.

Year	Vocational Student-Hrs	Math & Science Student-Hrs	Liberal Arts Student-Hrs	Unemployment Rate (%)	Average IQ	Avg # of Weeks To Get a Job
1	792	1188	1620	6	105	14
2	756	1332	1512	5	115	6
3	864	1296	1440	5.5	109	9
4	864	1080	1656	4.5	112	14
5	936	1224	1440	3	117	3
6	864	1260	1476	3.5	111	5
7	432	1368	1800	7.5	94	24
8	1008	1152	1440	6	108	13
9	864	1116	1620	4	97	13
10	504	1368	1728	5	115	19
11	648	1260	1692	6	100	15
12	828	1116	1656	5.5	97	14
13	612	1404	1584	4.5	114	11
14	1008	1152	1440	4.2	103	7
15	648	1332	1620	5.5	106	11

Table B-2 Fifteen-Year History of School Outputs, External Factors and Outcomes

To determine how the time to obtain a job is affected by the educational experience, the unemployment rate, and the average IQ of the graduates, the data in Table B-2 was analyzed using statistical software. The objective of the analysis was to determine a set of coefficients (weighting factors) that represent the relative influence of the multiple independent factors (in this case, student-hours, IQ, and unemployment rate).

The approach to determine the relative weight of all of the factors influencing the objective requires that all of the variables be independent of each other, but only two of the three instructional Outputs (vocational instruction, liberal arts, and math and science) are independent because the third is constrained by the amount of time left in the school year. Therefore, it was first necessary to determine which two Outputs had the most influence on the desired Outcome. Vocational training and math and science instruction were found to be most relevant and therefore were included in the regression analysis. (Liberal arts instructional hours were dropped because they were found to not strongly influence the objective of rapid transition to the adult workforce. However, there is little doubt those hours would contribute to the second strategic objective, that of preparing the student for higher education, whereas the analysis in that instance would likely show vocational training to have little impact.)

Preliminary results also revealed that the effects related to the average IQ were not statistically significant, so the IQ External Factor was also dropped.

The influence of the most significant factors, all of which are in excess of 99% confidence, are graphically displayed in Figure B-1. Note that the amount of Math & Science Hours and Vocational Hours both tend to decrease the time to get a job, while an increase in the unemployment rate tends to increase the time.

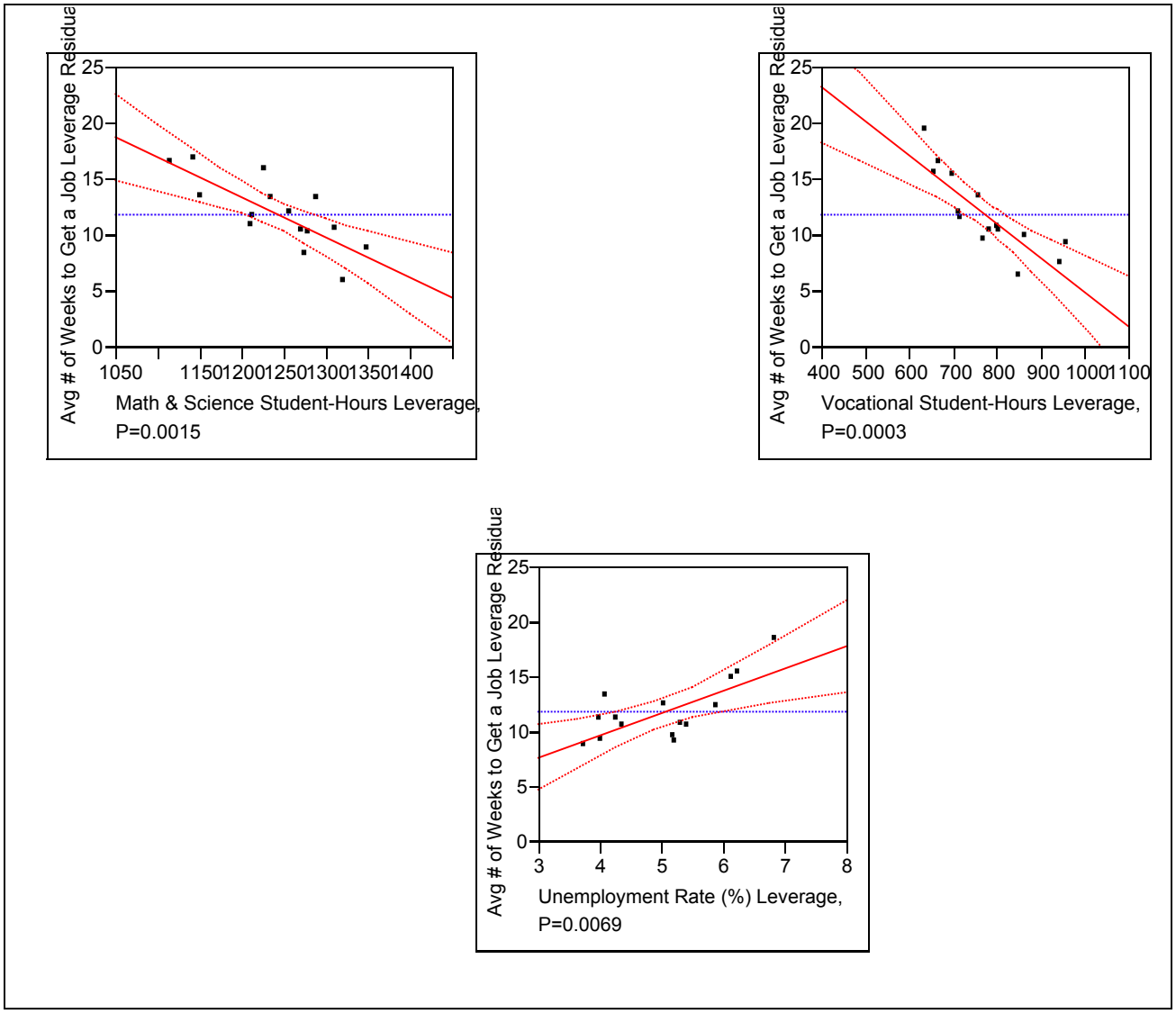
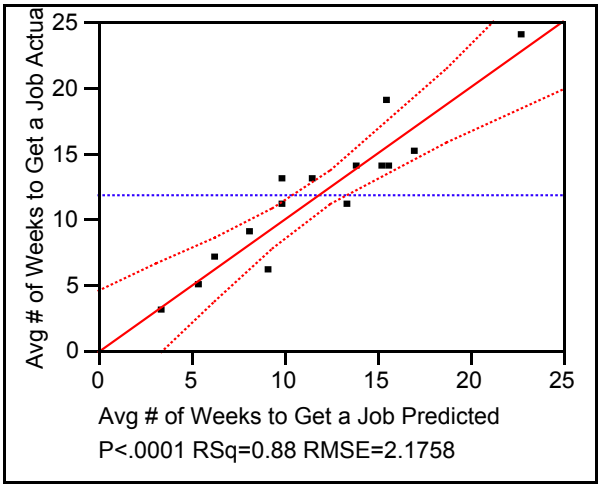


Figure B-1 Influence of Math/Science Hours, Vocational Training Hours, and Unemployment Rate on the Time to Get a Job

Taken together, the results can be used to *predict* the time to get a job, given the number of instructional hours in Math & Science, the instructional hours in Vocational Training, and the Unemployment Rate, Figure B-2 shows how the predictive equation compares to the actual data, and the section labeled Parameter Estimates details the weighting factors for these three parameters.



Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	70.016024	15.80399	4.43	0.0010
Vocational Student-Hours	-0.030587	0.005911	-5.17	0.0003
Math & Science Student-Hours	-0.035915	0.008599	-4.18	0.0015
Unemployment Rate (%)	2.0233649	0.610878	3.31	0.0069

Figure B-2 Predictive Parameters and Plot of Actual vs Predicted Time to Obtain a Job

Figure B-2 can be interpreted as follows:

- The predictive equation represents the level of effectiveness of the education in the presence of the external factor (unemployment rate). Specifically, within the range of student-hours and unemployment rates experienced, one could predict the time to find a job through the following relationship:

  Time (weeks) = 70 – (0.0359 * Math/Science Hrs) – (0.0306* Vocational Hrs)
  + (2.023 * % Unemployment Rate)

  The coefficients of the Math/Science hours and Vocational hours represent the relative influence of those student hours in achieving the objective of minimizing the time to get a job, and one could interpret those coefficients as a proxy for the quality of the educational experience.

- The graph in Figure B-2 shows the differences between the actual time experienced to obtain a job and the predicted times, using the predictive parameters shown beneath the plot. Approximately 88% of the variation is explained by the parameters. The overall confidence level that the relationship is meaningful exceeds 99%

- The standard deviation of the prediction estimate is 2.17 weeks.

- The parameter estimate table in Figure B-1 indicates that the math and science subjects have a slightly stronger effect on the desired objective than do the vocational training hours, but they are quite close in their influence (.036 vice .031)

- The unemployment rate is a significant factor; each 1% increase in unemployment adds about two weeks to the job search process and for each 1%, it would take an additional 60 hours of math and science instruction or 70 hours of vocational instruction or some combination of both, to counter that unemployment rate effect.

As an example of the application of these results, suppose a persistent unemployment rate environment of 5% was anticipated, and the planned amounts of student-hours in Math/Science and Vocational Training were 1200 and 800 hours respectively over the course of the four years of instruction. The foregoing relationship indicates that the school should expect the average time for a student to get a job after graduation to be approximately 12 weeks. If that were considered unsatisfactory, the school system would have insight as to how much they would have to increase the number of student-hours in the relevant subjects in order to improve that Outcome Indicator.

It is important to realize that the foregoing equation predicts the resultant Outcome based on the number of instructional hours delivered *at the level of effectiveness reflected by the data over the 15 year period.* The resultant coefficients associated with the student hours of instruction (the factors under control of the school) provide a very useful benchmark against which changes in the curriculum, changes in instructors, and changes in instructional delivery can be evaluated. The school should work to improve the Outcome for the same number of instructional hours that are delivered or conversely, work to achieve the desired Outcome with fewer instructional hours. Having measured the quality of its education in terms of progress toward its strategic objective, the school is in a position to evaluate any changes made in an effort to improve it.

The foregoing illustrates how planned organizational Outputs, in this case student-hours, can be tailored to better achieve progress toward the organization's Strategic Objectives/Outcomes, but even if the results of the analysis are not used in a predictive manner, it is very useful to know which Outputs and External Factors have the most influence upon a particular Strategic Objective.

As to the second Strategic Objective, that of preparing the graduates for higher education, a similar approach could be used to measure effectiveness. The data for the Outcome Indicators of Verbal and Math SAT's would be much easier to obtain, and the school's Outputs would be as previously described (in the form of student-hours of instruction in the various courses). External factors would perhaps be IQ once again, and perhaps a scale that represented socio-economic class, if such information was available. It would likely prove useful to perform independent analyses of the factors influencing the Verbal SAT and Math SAT, in both cases using the same approach as has been demonstrated.

With all of the results in hand regarding the factors that were influencing all of the school's Strategic Objectives, the school would be very well informed and would be in an excellent position to make the trade-off decisions necessary to ensure that school's curriculum was balanced accordingly.

Conclusion:

This example has focused upon techniques to measure education quality, but with some effort applied toward gathering cost information as well, a school system is in a position to develop the following indicators of performance, both on an aggregate basis and for each academic department:

- Cost per instructional hour (cost efficiency of the school's Activities)
- Student hours per instructional hour (operational efficiency)
- Cost per student hour (cost efficiency in delivering the school's Outputs)
- Progress toward Strategic Objectives (as represented by Outcome Indicators) as a function of the number of student hours of instruction (operational effectiveness)
- Progress toward Strategic Objectives as a function of the cost of delivering the student hours of instruction (cost effectiveness)

Pursuing such performance indicators takes effort, but given sufficient data, most school systems should not have difficulty in making those measurements.

Education is but one example of the application of these concepts. It is always essential to ensure that a public sector program is operating efficiently, and generating the efficiency indicators described is not a particularly difficult task. Evaluating effectiveness is more of a challenge, but the analysis described herein provides a roadmap to follow.