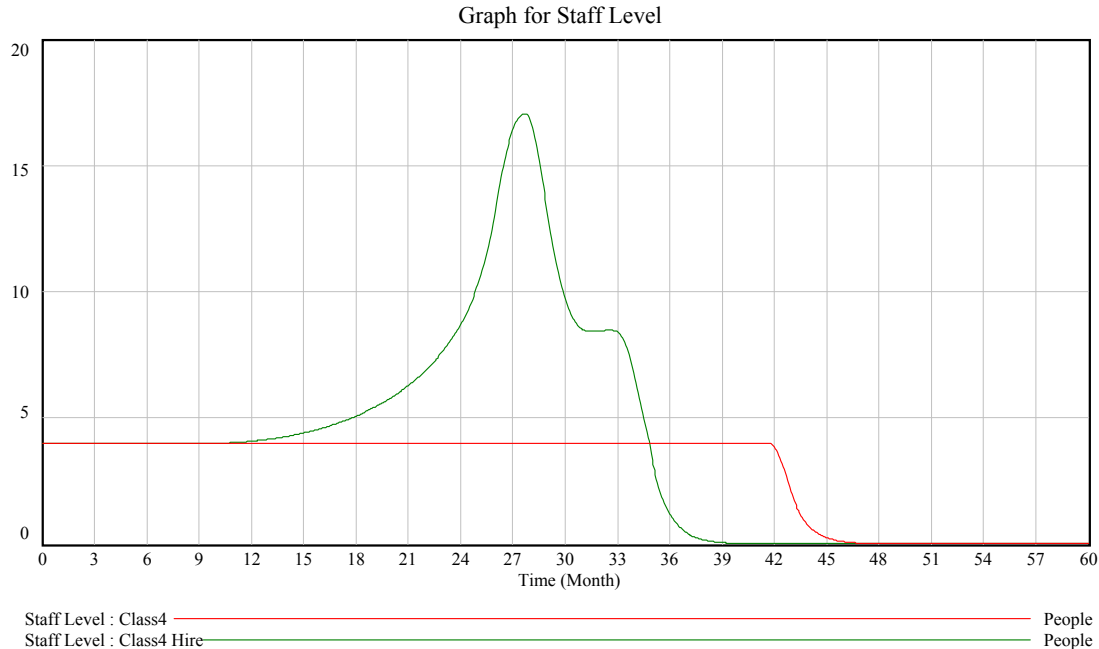


Homework 4 Solution Notes

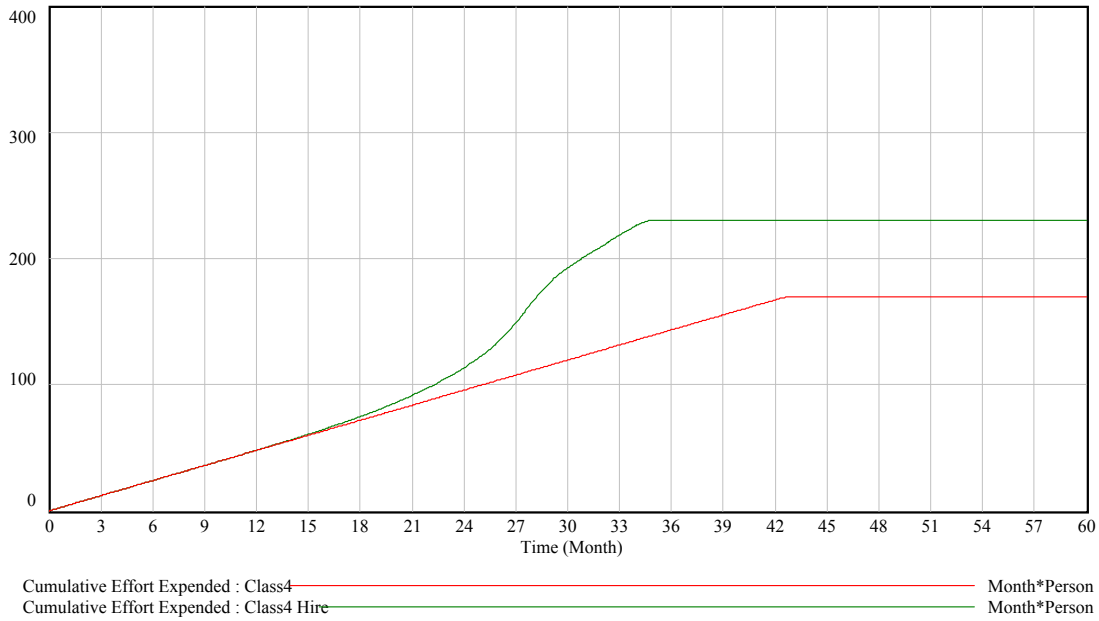
Understanding Staffing Dynamics on Product Development Projects

1. Download the Class4 model from the server. Simulate the model with no hiring (willingness to hire = 0). Now simulate the model with hiring (willingness to hire = 1) [Only 2 simulations are required to answer this question.] (a) How does hiring affect the cost and the schedule performance of the project? [Cost is measured in this simple model by cumulative person-months spent on the project.] (b) Why does the project cost more? [Be sure to include Vensim output which explains why costs (person-months) increase] (c) Why does the project still finish behind schedule? [Again be sure to include Vensim output which explains your answer.]

Without any hiring, the project finishes 15 months late (month 43 vs. scheduled completion date of month 27), because 4 staff are insufficient to get the original scope done on time given the amount of rework that occurs on the project. When the project is allowed to bring on additional staff, it finishes in month 35 (still 7 months late), and the cost increases significantly (230 person-months vs. 170 without hiring). The next two graphs show the behavior of staff and "cost" (cumulative effort expended in person-months) for the two simulations.

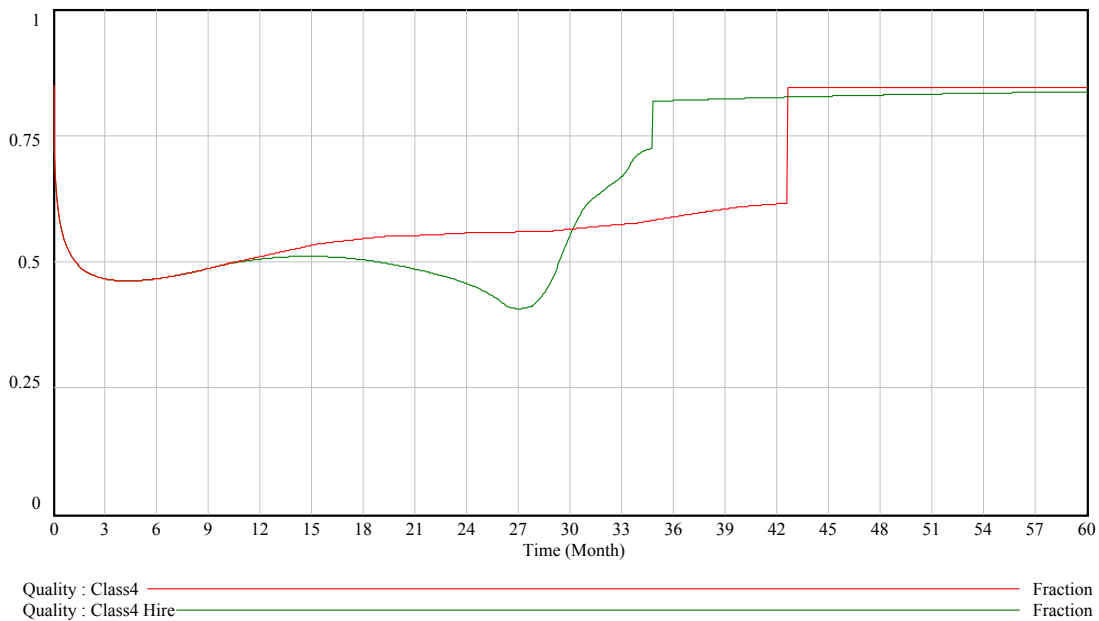


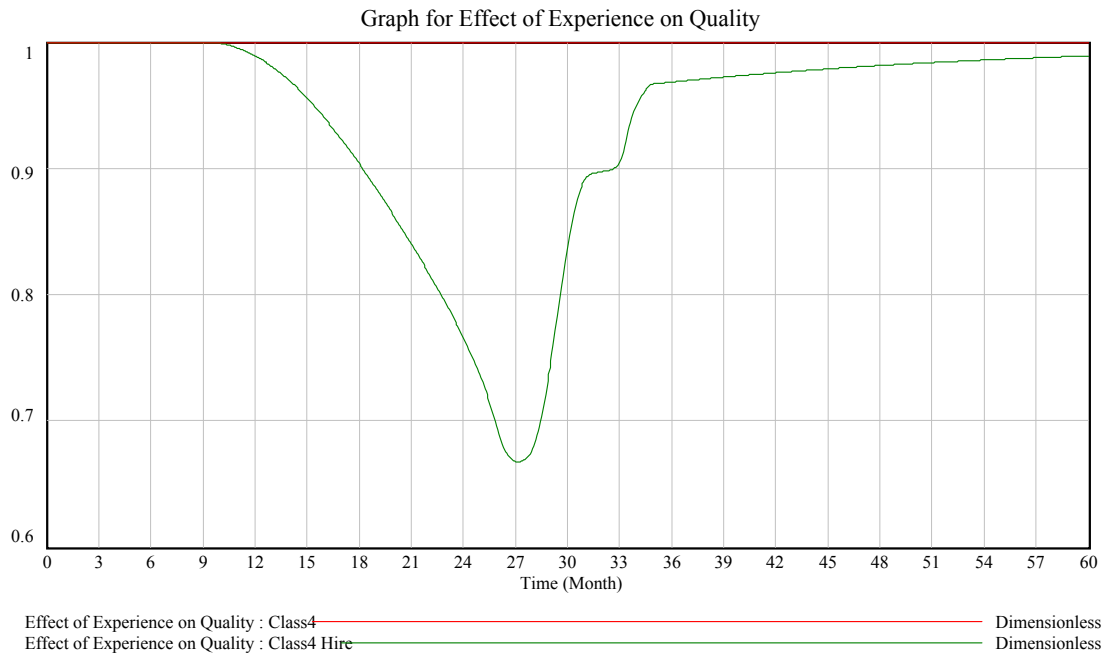
Graph for Cumulative Effort Expended



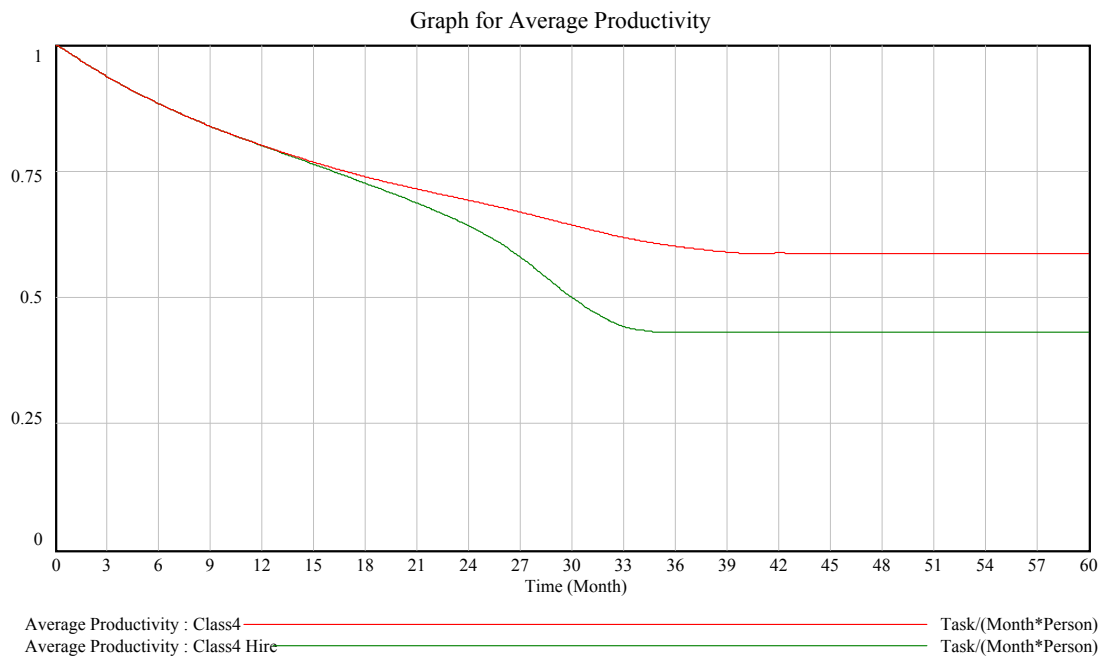
Why does the project cost more? Hiring inexperienced people reduces productivity and work quality, as indicated in the graph below for quality (behavior of productivity is similarly affected), and the following graph for effect of experience on quality. A plot of rework done and total work done would also be important here.

Graph for Quality





Why does the project still finish behind schedule? Because of delays in hiring people, and because we overestimate the net progress that these new staff will make. New staff work at lower productivity and make more errors than the original experienced staff on which the hiring decisions are based. The graph below shows that average productivity, the basis for estimating staffing needs, is lower and declining during the hiring period -- hence we underestimate staff needed.



2. In 1975 Frederick Brooks wrote a book entitled The Mythical Man Month, in which he described his experiences managing IBM's development of the mainframe 360 hardware and software (updated in 1995).¹ In that book, he coined what came to be known as "Brook's Law:" "Adding manpower to a late software project makes it later." In this question, you will use the Class4 simulation model to assess the validity of the Law. The parameters in the model which directly relate to the law are relative productivity of new staff; relative quality of new staff; hiring delay; and time to gain experience. Assuming that these parameters are sufficient, design a set of experiments to test the validity of the law. I.e., simulate the model with higher and lower values for these parameters *[Be sure to test extremes; for simplicity, you can assume that the relative quality and productivity of new staff always move together.]* Under what conditions does his "law" hold (briefly explain why)? When is his "law" invalid (again, why)? *[No more than 6-8 additional simulations are required to answer this question. Provide summary tables/graphs and selected simulation output to support your answer.]*

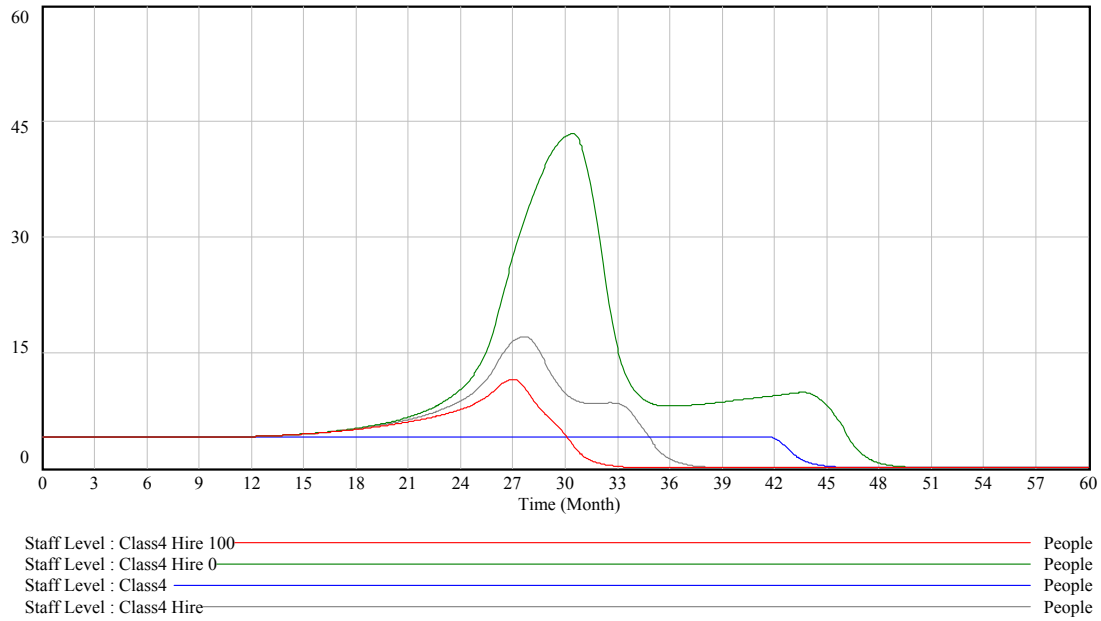
[For this question I did three additional simulations (shown here anyway, I've done lots more!): (1) Class 4 Hire 100, where the relative productivity and quality of new staff is 1.0, or the same as experienced staff; (2) Class 4 Hire 0, where the relative productivity and quality of new staff is 0 (perhaps because they are in training at first, or becoming familiar with the project; they gain experience very soon, however); and (3) Class 4 Longer Time to Gain Experience (48 months). Students should probably do more simulations, for example examining additional values for relative productivity and quality, time to gain experience, and hiring delay.]

If additional staff can be hired at the same productivity and quality as existing staff, then the project can finish nearly on time with little additional cost (see summary table and staffing graph below). However, as the amount of experience "dilution" increases, cost and schedule delay increase from this no impact situation. At some point, the experience dilution becomes large enough that the project actually finishes later than the no hire case (as well as costing significantly more). The impact of experience dilution on quality is illustrated in the graph further below. Increasing time to gain experience from 24 to 48 months has relatively little impact. Given that most of the hiring occurs in months 27-30, and the project only lasts another 5 months or so after that, the change in time to gain experience is minimal (see effect on quality graph).

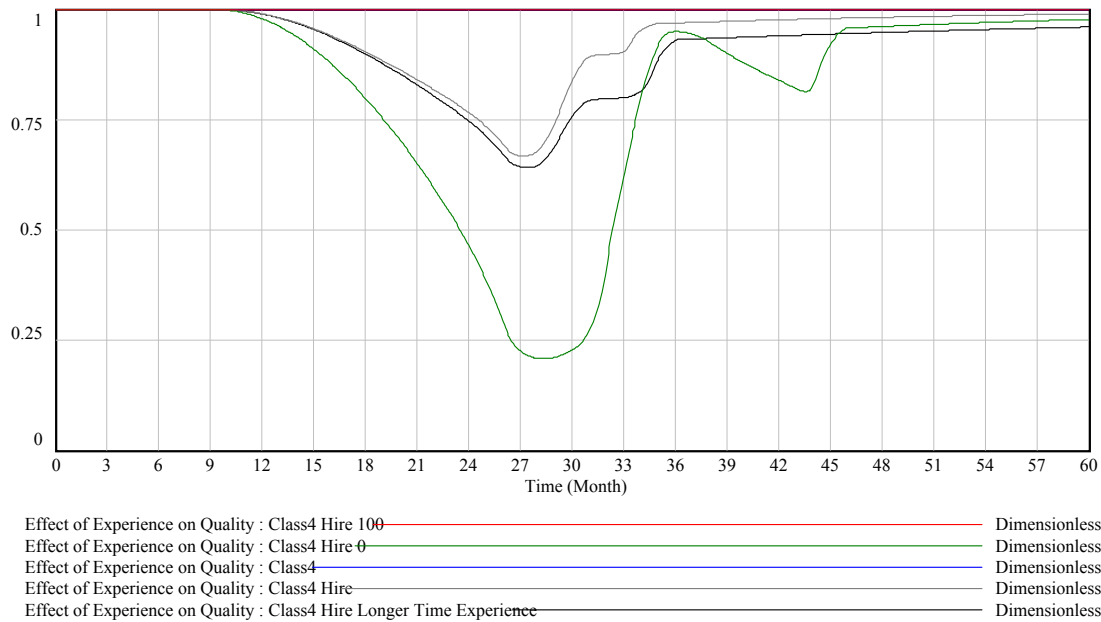
<u>What-If Test</u>	<u>Project Finish (Month)</u>	<u>Project Cost (Person-Months)</u>
No Hire	43	170
Hire at 1.0	30	165
Hire at 0.5	35	231
Hire at 0.0	46	493
Hire at 0.5, 48 mos. To gain exp.	36	248

¹ Brooks, Frederick P. Jr. The Mythical Man-Month. Reading, MA, Addison Wesley, 1995.

Graph for Staff Level



Graph for Effect of Experience on Quality



Therefore, Brooks' Law holds when the experience dilution impact of new staff is significant. If new staff can be brought on with modest or no dilution impact, then the project will finish earlier than it would have by adding manpower. Remember that in this simple model the experience effect also captures the impact of other "size" changes on productivity and quality, including

organization size, draining time from experienced staff, etc. Therefore, it seems that the experience effect is more likely to be significant than small.

3. Brook's Law deals only with schedule. What are the cost implications of adding manpower to a development project? Do they differ from the schedule implications? Is there a cost-schedule tradeoff? *[Probably no additional simulations are required to answer this question.]*

The cost implications are given above. Generally, there is a tradeoff and schedule can be improved by adding people only at additional cost. At the extremes, however, the effect of adding people involves no tradeoff -- if there are no experience dilution effects, then schedule can be improved without any cost impacts; if the experience dilution impacts are significant, then adding staff increases both schedule and cost.

4. Comment on the implications/applicability of these results for different types of projects -- software projects, hardware projects, projects like the unmanned aerial vehicle in the previous assignments, and typical projects in your organization. Specifically: How strong is the effect of "experience" on productivity and quality in the different types of projects *[Remember that in this relatively simple model experience is used as a proxy for a number of separate effects, including different types of experience (on the project, on similar projects, as an engineer); dilution of experienced staff time; size, and changes in the size, of the organization]*? How are other parameters you found important likely to differ between the types of projects? What recommendations would you make for managers of the different types of projects about adding staff if their projects fall behind schedule.

In response to this question, students should state how they think the four different project/project types differ with regard to the strength of the effect of experience on productivity and quality, and on time to gain experience or hiring delay if they found these important. For example, they might argue that the experience effects are stronger on software projects than on hardware projects -- the exact answer does not matter; rather, the logic of their arguments. Similarly for recommendations. If they think the effects are strong, then adding staff is not the answer -- it will not only raise costs, but also make the project later; if the effects are middling, then the earlier finish will come at the expense of cost and the advisability of the tradeoff would depend on the product.