

Completing Learning

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The indispensable product of education and training is *learning*. Learning occurs *when* and to the *extent* that proficiency increases from the beginning to the completion of some process intended for that purpose. Please note that *proficiency* is the ability to do something well and under a variety of conditions. Learning is not maturation. *Maturation* is an increase in proficiency over time that is due to physical growth in order to reach maturity. Thus, without the education or training process, an increase in proficiency should *not* be observed. If improvement occurs with or without the process, then it would be attributed to maturation—not to learning. Unless learning occurs we do not really have education or training even though some might call it that.

Using a new measurement procedure¹ that reveals and quantifies any degree of deficiency with respect to any task or subject, we begin to explore the learning that does or does not take place in schooling and various training programs. This method yields a measurement of proficiency which predicts future performance even better than current success or failure on the task.²

¹ These publications provide the mathematical foundations while describing applications before computers became widely available: Emir H. Shuford Jr., Arthur Albert, & H. Edward Massengill **Admissible Probability Measurement Procedures** *Psychometrika*, 31 (1966), 125-145. Emir H. Shuford, Jr. **How to Reward Achievement** *Air Force ROTC Education Bulletin*, 12, 4, (April, 1970). Thomas A. Brown & Emir H. Shuford **Quantifying Uncertainty into Numerical Probabilities for the Reporting of Intelligence** Santa Monica: The Rand Corporation, R-1185-ARPA (July, 1973). Emir Shuford & Thomas A. Brown **Elicitation of Personal Probabilities and Their Assessment** *Instructional Science*, 4 (1975), 137-188. Emir H. Shuford **Scoring Systems, Studying, and Success** *Newsletter of the International Foundation for Computerbased Education in Banking and Finance*, 3, 3 (August 1993), 9-13.

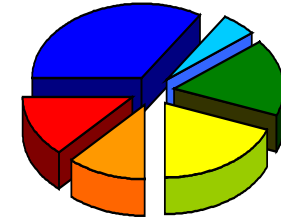
² Emir H. Shuford Jr. & Duncan L. Gibson **A New Method for Predicting Performance** Air Force Office of Scientific Research and Development, AFOSR-69-1329-TR, (May 1969). Emir H. Shuford **Predicting Task Success** CONVENTIONAL WISDOM SERIES No. 10, Applied Probability Technologies LLC (March 2000).

One way to look at the results is to categorize a person's proficiency on each problem as shown below.

| DIAGNOSIS | PATTERN | IMPACT |
|---------------------------|---|---|
| ASSURED | Strongly committed to correct solution | Correct action taken quickly, under stress and remembered longer. |
| HESITANT | More committed to correct solution than any other | Correct action taken more slowly, vulnerable to stress and forgetting. |
| PARTIALLY INFORMED | Undecided between correct solution and another | Some time required gaining needed information before acting, otherwise mistake is likely. |
| UNDECIDED | Not committed to any of the solutions | Much time required gaining needed information before acting, otherwise mistake is highly likely. |
| MISINFORMED | More committed to an incorrect solution than to the correct one | Time required resolving doubts in situations perceived as critical; otherwise a mistake is sure to be made. |
| DELUDED | Strongly committed to an incorrect solution | Incorrect action taken immediately without checking with supervisor, coworker or referring to manuals. |

Let us look first at a sampling of general knowledge. Taking the whole group of participants, how do the diagnoses distribute?

Figure 1. General knowledge from school & newspapers



As shown in Fig. 1 there are more instances of being **ASSURED** than of any other category, but with a lot of cases of being **PARTIALLY INFORMED** and **UNDECIDED**. That is not surprising. However, the relatively large percentage of **DELUDED**s can lead to a lot of mistakes and disagreements.

Consider now more specific knowledge—that used by educated and trained people working daily in a sensitive job where on any day they can make a mistake costing the organization millions of dollars.

Figure 2. Proficiency on the job: security policies & procedures

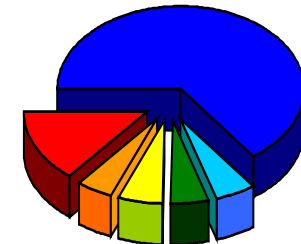
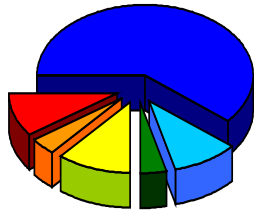


Fig. 2 shows as expected, there are many more instances of being **ASSURED**, but, unexpectedly, the percentage of **DELUDED**s is even slightly greater than before. Proficiency status has tended to move toward the extremes. Becoming **ASSURED** is, of course, what we want to happen, but each **DELUSION** is just an accident or mistake waiting to happen.

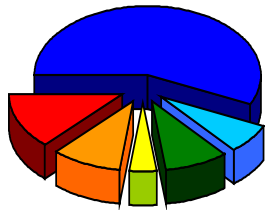
In order to take a closer look at this, consider these data from some training courses.³

Figure 3. Diagnoses upon completing a word processing program class



When assessed on the training objectives of a word processing class, as Fig. 3 shows, people were not as ASSURED and did not have as many DELUSIONS as did the more experienced people in Fig. 2. Note that classroom instruction and working with the computers resulted in many DELUEDEDS. How do people do when they start applying what they have learned to their jobs?

Figure 4. Two weeks after the word processing class

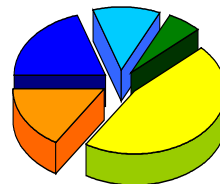


Here they are two weeks later as shown in Fig. 4. People have not gained in proficiency. They are worse off with fewer instances of being ASSURED and, surprisingly, more DELUSIONS. Experience doesn't seem to be helping them. People find it frustrating to use the software because of the incompleteness of their training. The usual forgetting may account for the decline in assurance while the fact they have been trained misleads them into more DELUSIONS and instances of being MISINFORMED.

³ Emir H. Shuford **Training Outcomes** CONVENTIONAL WISDOM SERIES NO. 4, Applied Probability Technologies LLC (June 1989).

Do you wonder how they did on the course objectives at the beginning of the class? Here in Fig. 5 is the answer.

Figure 5. Beginning the word processing class



Just what you would expect, no DELUSIONS and much uncertainty showing they know they don't know how to use the program. So, where do the DELUSIONS come from? It must be the training experience—they expect to gain knowledge and proficiency so they tend to go to extremes, but the classroom teaching, hands on experience on the computer and testing fail to detect, much less correct these DELUSIONS.

Maybe these findings are atypical. Take a look at a different subject, different students and different teachers.

Figure 6. Beginning a spread sheet software class

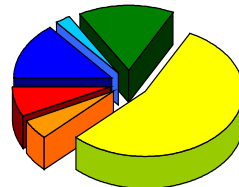
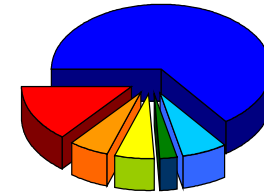


Fig. 6 is much like starting the other course except there are now some DELUEDEDS. Overall these students know that they don't know very much about the subject and they are ready to be taught.

⁴ Ruth Briggs **Wafer Fab Progress Report** PIONEERS SERIES NO. 1, Applied Probability Technologies LLC, (May 1994).

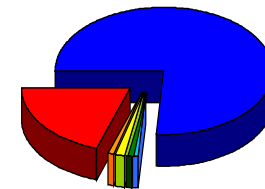
Figure 7. After completing the spread sheet class



A lot of the objectives of the course are met as indicated in Fig. 7 by the large increase in ASSUREDS. The number of DELUEDEDS, however, doubled—a most unfortunate result suggesting people will encounter difficulty using the spreadsheet program.

So far these classes have been short dealing with the use of specific software products. How about a six-month course of much greater scope?⁴

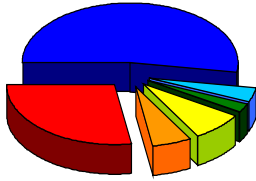
Figure 8. Diagnoses after completing Statistical Process Control Course



Notice these students in Fig. 8 wind up pretty much at the extremes with very little doubt about their mastery of the subject matter. The only problem is they are very wrong about one-fifth of the time. Again, we wonder how they started out at the beginning of the course. Did they develop these DELUSIONS during the course or did they have them from the beginning?

⁴ Ruth Briggs **Wafer Fab Progress Report** PIONEERS SERIES NO. 1, Applied Probability Technologies LLC, (May 1994).

Figure 9. Diagnoses when beginning Statistical Process Control Course

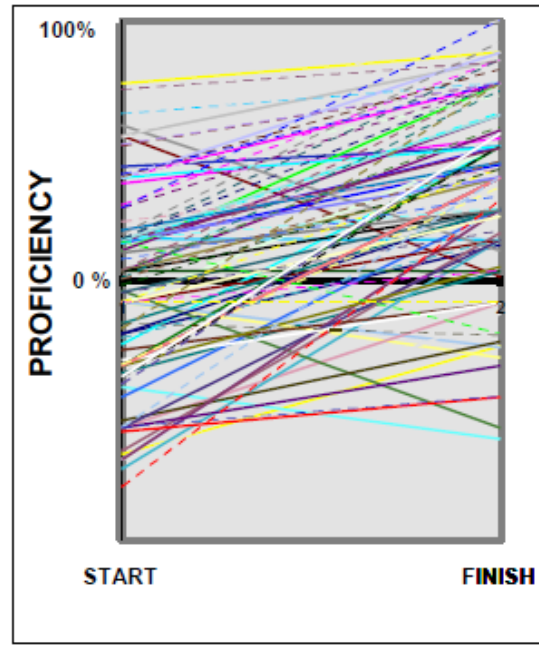


As you can see in Fig. 9, they appear to have most of them from the beginning. There are also many **ASSURED**s from the beginning. The course greatly reduces the proficiency while quite a few manage to decrease their intermediate diagnoses, largely converting them into **ASSURED**s. It does this while slightly reducing the **DELUSIONS** which seem to be resistant to correction in a classroom setting. They are seldom detected even when a question period follows a lecture.

The data we have seen so far show that classes can produce learning in the class as a whole although the final results leave much to be desired assuring that many mistakes will be made in applying the subject later.

How do things look on an individual level? This new measurement procedure quantifies proficiency on a scale going up to 100% or complete mastery of the measured material. A person not knowing the subject and realizing it and just beginning the learning process would score in the vicinity of zero percent while a person with a number of **DELUDED** and **MISINFORMED** can very easily earn a negative score reflecting the harm that this can lead to as shown in Fig. 10 for the same course described above.

Figure 10. Changes in proficiency from beginning to end of six-month course



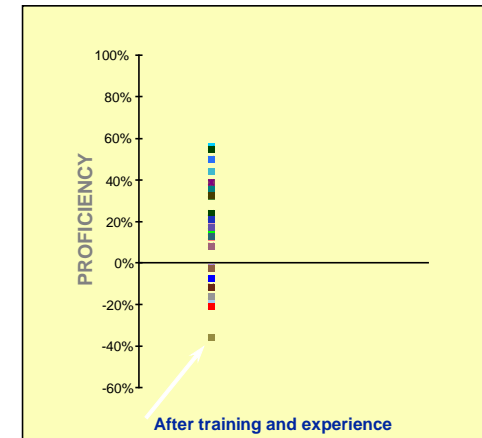
These experienced people, being educated for an initiative to transform the organization,⁵ start the course with proficiencies ranging from near 80% down to about -80%. They finish the course with proficiencies ranging from 100% (one person) on down to about minus 65%.

Many people increase their proficiency while quite a few manage to *decrease* their proficiency. A little learning *is* a dangerous thing especially for those who lose greatly in proficiency like the person going from almost 60% down to about 0% and the person going from slightly below 0% proficiency down to about minus 60%.

⁵ Emir H. Shuford, **Effect of Education CONVENTIONAL WISDOM SERIES NO.5**, Dallas, Texas: Applied Probability Technologies, LLC, September 1994.

Remember too that incomplete learning can have consequences far beyond making a good grade and passing or failing. Another organization operating in a complicated and potentially dangerous activity emphasizes safety for all people.⁶

Figure 11. Proficiency after successfully completing safety course and testing.



People attend classes on safety policies and procedures and the reasons for them and then pass a written test to assure their mastery of the subject. Here are the results in Fig. 11 with each data point representing one person.

These proficiency measurements use many problems covering all subjects and most of the objectives of the safety course.

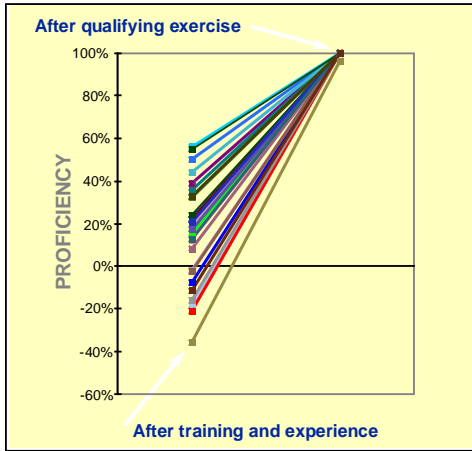
Notice that no one reaches or exceeds 60% while some earn negative scores reaching down to a minus 35%. This is not a happy state of affairs and one might be apprehensive about working with some of these people.

⁶ John Wiley & Emir H. Shuford **Preventing Accidents** With John Wiley, PIONEERS SERIES NO.5, Dallas, Texas: Applied Probability Technologies, LLC, June 1998.

Is this the best that can be done to insure the safety of the people in the organization?

Using the new measurement procedure to guide and reward the further learning of these adults and then confirming mastery by setting a goal of 95% or above produces the results in Fig.12.

Figure 12. All mastered safety when they worked to eliminate any and all deficiencies.



These adults are now able to find out any deficiencies in proficiency, as revealed by the new measurement procedure, and to correct them as they proceed. This is a much happier state of affairs and one might feel better about working with these people.

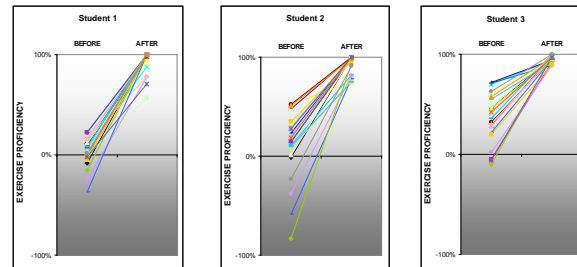
Similar results where all complete and perfect their learning using the new technology as a guide occur many times with adults in business and industry. Does this happen with children?

The results below are for an Advanced Placement class⁷ on U.S. Government.⁸

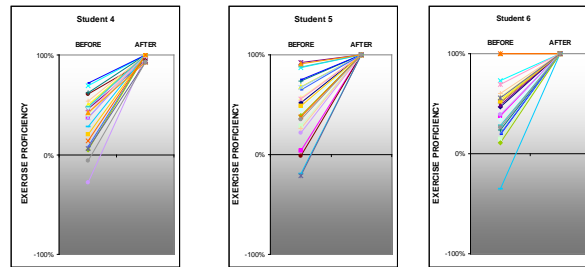
⁷ Richard E. Lombardi **Classroom & Home Schooling PIONEER SERIES NO. 10**, Applied Probability Technologies LLC (March 1998).

All the data in the graphs below are for students who first used the new measurement procedure towards the end of the course so the data points on the left labeled BEFORE show proficiency as a result of classroom lectures, homework assignments and projects and reports with each point representing an exercise containing twenty to thirty problems based on the subject matter.

As before, the proficiency levels from classroom instruction leave much to be desired even realizing that last minute studying prior to the final exam may serve to improve them. Each student could, as homework, work with the technology at home, in the library, and so on to improve proficiency on each of the exercises so as to earn a good homework score contributing to the grade for the course. Student 1 starts out without much proficiency clustered around zero percent but works to build it up to markedly higher levels ranging from 60 to 100%.

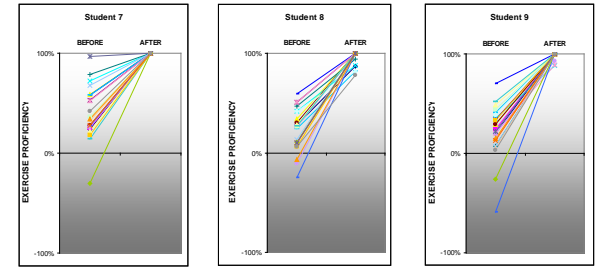


Student 2 starts out with an even wide range of proficiencies but is still able to improve markedly. Students 3 & 4 learn more from the class but go on to improve proficiency up to high levels of performance.

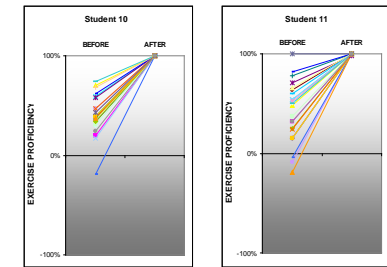


⁸ Richard E. Lombardi **Government & Geography Samples PIONEER SERIES NO. 11**, Applied Probability Technologies LLC (May 1998).

Students 5, 6 & 7 go on to achieve 100% on all exercises and thus, on all the problems.



Students 8 & 9, as did Students 1 & 2, started out lower, improved markedly but still tended to fall short of 100% proficiency. Further effort and study probably would have remedied this. Students 9, 10 and 11 went on to achieve 100% mastery as did Students 5, 6 & 7.



All these students prove to be learning in class but then go on to perfect their learning using the new technology.

In conclusion, these and many similar findings using the new technology reveal that education and training, even that considered state-of-the-art and benchmark quality, leave much to be desired in terms of proficiency and performance with the subject. The new technology reveals any deficiency of even the smallest degree to the student and can serve as a guide and reinforcement leading to the completion of learning of the subject matter. It is better to “keep your eye on the ball”. The ball, of course, is *quantified* learning and proficiency. Now, we can show students exactly what they need in order to do this and thereby establish new standards of achievement, effectiveness and economy.