Scientific Studying: Increasing Learning Power through Experiments

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Abstract

We address the massive waste of intellectual resources caused by inefficient and ineffective studying by students all over the world. More specifically, we propose a study methodology that may significantly improve the learning power of students, as well as of anybody that intends to learn more efficiently and more effectively (for instance, researchers, managers, etc.). We define 'Traditional Studying' as the suboptimal methods of study that are widespread in all institutions from primary schools to universities. We re-explore the Scientific Management [1] in order to provide a remedy to this waste, namely a studying methodology that is no longer the result of a number of inputs learned unconsciously and applied mechanically since early childhood, but which crucially takes the scientific self-experiment as the centerpiece method leading to the achievement of a significant increase in learning power.

Through personal observation, a student often emulates the way an older sibling or a classmate studies. We ask the question whether these methodologies are optimal. We conclude that unless scientific experiments are conducted, it is impossible to know whether or not the methodologies used by the students are the optimal ones. Through a number of experiments we conducted with middle and high school students, we have proven that is possible to increase one's learning power by fifty percent in just a few months. Furthermore, the experiments revealed, for instance, that the increase of learning power in Math (often perceived as a rather – if not most, in some cases – difficult subject matter) has been significantly higher than the average increase in learning power. Our findings have far reaching consequences as they are compatible with theories on the modifiability of intelligence such as [2], and confirm studies revealing that brain activity (such as a decision-making task) increases more rapidly following a time of intense physical activity [3].

The innovative methodology we propose has the potential to significantly contribute to the improvement of the level of education around the world, through a series of self-designed and self-administered scientific experiments, thus implying little or no investment by the institutions but potentially yielding enormous beneficial results for our society.

1. Introduction

We aim to substitute the non-scientific study methodologies used by students all over the world with a scientific methodology we name Scientific Studying, allowing for a considerable improvement in learning power. Our proposal raises awareness that only scientific, unbiased experiments can help each individual find the best possible way to study, in addition to providing the tools to find one's own optimal way to study. Scientific Studying can increase anyone's learning power, with incommensurable effects in our society's development through significantly improving the levels of knowledge and education.

2. Scientific Management

A century ago Frederick W. Taylor and Frank B. Gilbreth revolutionized the organization of manual work by applying Scientific Management (henceforth SM) and obtaining phenomenal increases in productivity (generally a minimum of 100%). In his work The Principles of Scientific Management [1], Taylor stated that the same principles might be applied to all kinds of human activities to remove the inefficiency in almost all human acts. We propose an application of SM to the very important field of learning, an application that we name "Scientific Studying". Based on experiments that show that the learning power of students may be increased by 50% in a few months, we believe that the impact of Scientific Studying could be as outstanding as the one obtained by Taylor and Gilbreth a century ago.

Taylor started from President Roosevelt's famous remarks that the country was suffering not only from waste in natural resources, but -more importantly- from 'larger wastes of human effort'. Taylor's remedy for this widespread waste was SM, whose basic concept is extremely simple: repeatedly execute several scientific experiments on the way the blue-collar workers work in order to improve their productivity. More specifically, these scientific experiments were conducted on the work methods, parameters, and implements, that is, the work methodology used by manual workers in their activities. The experiments were both designed and executed under the supervision of a manager, who measured and documented the results of the experiments. The optimal methods, parameters, and implements were determined and subsequently applied by the workers. A substantial increase in productivity was thus obtained.

The experiments conducted by Taylor and Gilbreth prove that, notwithstanding the millions of people who worked in the field of bricklaying for thousands of years, no related comprehensive science was developed until a hundred years ago. It is therefore not surprising that at the less visible level of studying, and more in general of learning, a similar situation may still be the case nowadays.

3. Scientific Studying

3.1. Key Assumptions

The basic concept of Scientific Studying is the same as the one of SM and, as such, extremely simple. Namely, that scientific experiments must be executed by the student on him- or herself (possibly but not necessarily with the guidance and support of an instructor) in order to increase effectiveness and efficiency during the time dedicated to the study activity, that is, to increase what we define as "learning power." More specifically, the student has to scientifically experiment and fine-tune study methods, parameters, and implements in order to determine the ones that allow the achievement of the highest increase in learning power.

Two key assumptions are at the base of Scientific Studying:

- There is a significant level of waste in the learning activity of students all over the world. By "waste" we mean that students generally study using a suboptimal methodology, which we define 'Traditional Studying', and which is often the result of a number of inputs learned unconsciously and applied mechanically since early childhood. Through personal observation, a student often emulates the way an older sibling or a classmate studies. It is extremely rare that a student without exposure to Scientific Studying would consciously plan for a number of different scientific experiments and diligently execute and document them in order to maximize his or her learning power. Even assuming that this took place, it would not have the power of Scientific Studying, as it would lack the communication feature of science.
- A scientific method can be successfully used to solve this waste. By "scientific method," we mean a method that satisfies the requirements of being unbiased, conscious, measured and documented, and communicated, essentially following the pattern *experiment, measurement, analysis, documentation, new experiment*, and so forth.
- We propose to shift study methodologies from nonscientific to scientific, and thus aim to reach impressive productivity improvements, which would in turn revolutionize education. Crucially, our proposal is not about a particular methodology in and of itself, but rather about the importance of being open to scientific experimentation and allowing oneself to scientifically experiment with different methodologies in order to find the winning one.

3.2. Main Theoretical Assumptions

We define intelligence as the ability to learn, and we assume that this ability may be substantially improved. This is in line with Feuerstein's theory of intelligence, where "[the intelligence] is not 'fixed', but 'highly modifiable'" [2], based on evidence of neuroplasticity. "In contrast, when intelligence is conceptualized in quantitative terms, as a fixed product of ability that it is constant across the entire lifespan of the individual, the natural outcome is a passive acceptance approach" [2].

Furthermore, we hypothesize that not only is intelligence highly modifiable, but, crucially, it is easily modifiable. Our experiments show a significant improvement in the levels of learning power achieved in a relatively short period of time. Scientific Studying, just like Feuerstein's approach, is counter to the passive acceptance approach by demanding conscious and active participation of the subject for his or her own cognitive improvement. We agree with Feuerstein in that belief is a necessary ingredient to achieve modifiability, that is, improvement of learning capacity. The student, as well as the instructor (if any), must deeply believe that an improvement in learning capacity is possible. They also both need to have an open mind (which is a fundamental prerequisite to the scientific method) to the scientific experiments, and willingness to execute them. In fact, the more the subject is determined to succeed, the better the improvements; lower levels of engagement in one's own self-improvement result in small or no increases in learning power.

We assume a Galilean approach to science, where hypotheses are tested through experimentation that confirms or refutes the hypotheses. Going further than the Aristotelian approach to science, which was merely contemplative but still based on the belief that knowledge is obtained through empirical observation, the Galilean approach relies on the objectivity of the scientific method. Scientific Studying assumes the superiority of the scientific method over all other methods to improve one's ability to learn and therefore his or her intelligence. Moreover, the scientific method may be more deeply grounded in our beings than we are tempted to think. Gopnik et al. [4] contend that children learn through experiments: "Children learn about the world much as scientists do—in effect, conducting experiments, analysing statistics, and forming theories to account for their observations" [4]. Therefore, humans act quite scientifically in the first years of their life, when their learning power is at the zenith, but seem to partially lose such ability later in life. Ultimately, Scientific Studying is about restoring such ability within a structured framework. Such predisposition for the application of a scientific method can be retrieved at any given time. Moreover, humans are able to change how they learn (cf. [4]) which confirms that our task of finding a better way to learn is feasible.

3.3. Scientific Studying as a scientific experiment

The centrepiece of Scientific Studying is the scientific experiment. In order to be scientific, the experiment has to satisfy certain specific requirements, namely be unbiased, be conscious, be measured and documented, and be communicated. This stands radically opposed to the Traditional Studying methods employed – almost automatically – by students around the world.

Table 1 resumes the main differences between Scientific Studying and Traditional Studying.

	Traditional Studying	**Scientific Studying**
Goal	Study (the way we are used to, the way we feel, the way we naturally do, etc.)	Study (using an optimal methodology)
Methodology	Acquired through a number of inputs learned almost unconsciously during several years, since early childhood	Acquired in a relatively short period of time (typically a few months to one year) through a number of scientific experiments conducted by the student himself/herself (with or without the help of an instructor) on methods, parameters, and implements, starting with a methodology that proved optimal for a majority of subjects in previous experiments
Characteristics	• Mostly unconscious and unplanned • Mostly unaware of the existence of waste and entropy • No conscious self-observation	• Strictly conscious and planned • Conscious goal of reducing or eliminating waste and entropy • Conscious goal of maximizing the learning power • Conscious self observation
Prerequisites	• None: the student is not formally exposed to "learn how to learn in a scientific context"	• Formal exposure to "learn how to learn in a scientific context"
Separation of planning and execution of work/study	• No: they are randomly mixed together	• Yes: the student plans first and executes later
Measurements and communication of results	• None: there are only individual isolated study methods	• Formal measurements and communication of results, in view of further developing them

Table 1. Comparison between Scientific Studying and Traditional Studying

The tool kit of Scientific Studying contains:

- Methods: One example of method is the separation of the time dedicated to study into study activity and recreational activity. Time management is a crucial element in the implementation of Scientific Studying (as it was in SM). During the study activity—but this is true of any activity—it is critical to clearly identify the time dedicated to study as opposed to the time dedicated to recreation. The natural tendency is to mix the two, resulting in an important loss in productivity. The way to avoid such loss is to appropriately plan, in writing, for a specific time segment for study and a specific time segment for recreational activity. This detailed planning can cover the day or simply a few hours. The detailed plan may be drafted on paper and placed in a very visible way, along with a watch to keep track of the time.

Moreover, as an added experiment, subdividing time provides better learning power when used in conjunction with alternating the subject matters that are being studied. In the experiments we performed, time segments of fifteen or twenty minutes yielded the best results. Thus, for instance, a student would study Literature for fifteen minutes, followed by History for fifteen minutes, Math for fifteen minutes, then take a fifteen minutes pause, before continuing with another round of study segments. This typically contributes, according to our results, to the efficiency and effectiveness of the study activity. A shorter time frame allotted per subject matter renders the study more focused. This is easily understandable considering that the smaller the time segment, the smaller the time wasted: in a small time segment, even a minimal waste of time will have a relative large ratio of wasted time on allocated time. For instance, five minutes' waste on a two-hour interval (120 minutes) is 5/120=4.2 or 4.2% of the overall time. However, five minutes of wasted time on a total of twenty minutes is 5/20=0.25 or 25% of the overall time, thus much larger percentagewise and therefore more visible and easier to detect and control. This is in sharp contrast to Traditional Studying, which typically consists of studying one subject matter for a prolonged period of time.

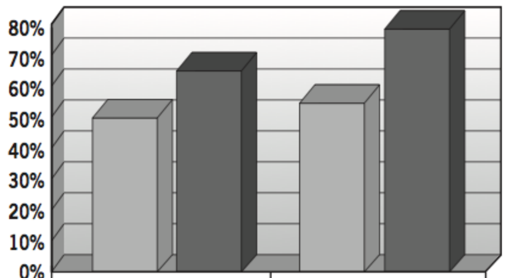
- Parameters: The parameters are, for instance, in the case of the subject matter alternation method, the length of the study intervals, as well as the length of the recreational activity.
- Implements: The implements are, for instance, a music player (studying with or without the music), markers (underlining or not important concepts, etc.), pens or pencils, and so on.

4. Experiments

We conducted four sets of experiments with middle and high school students over a period of eight months. We measured the increase in learning power based on two factors: marks and average time dedicated to the study activity, or more specifically:

- Average marks before the experiments, as compared to average marks after the experiments, calculated both by subject matter and by overall average. The increase or decrease in average mark is calculated through a weighting process taking into consideration the overall mark distribution in the school. For example, a 100% improvement (in terms of marks only) is obtained if the student improves from the lowest score of all the students in the school to the highest. Since all this is subject to a weighting process, the higher the density of marks in the segment representing the absolute increase, the higher the percentage increase as compared to the absolute increase.
- Average number of hours dedicated to study before the experiments, as compared to average number of hours dedicated to study after the experiments.

By using both measures i and ii outlined above, we calculated an index that quantifies the percentage increase in learning power, which is directly proportional to i above and inversely proportional to ii above. The results have been strong across the entire spectrum of experiments. We illustrate in Table 2 below the results of the first three sets of experiments, while the full results are detailed in [5].



	Average	Median
Overall	50%	55%
Math Only	66%	79%

Table 2. Improvements in learning power (recreational time included) for the first three sets of experiments

Fourteen students participated in the first three experiments. Eleven students achieved impressive improvements of overall learning power, from a minimum of 23% to a maximum of 79%, with an average of 50% and a median of 55%. For Math, the improvement of learning power ranges from a minimum of 24% to a maximum of 109%, with an average of 66% and a median of 79%. The improvement in Math was therefore much larger than the average improvement. It is generally accepted that Math is a subject matter more difficult than average, and therefore we can conclude that Scientific Studying makes it easier to approach more difficult subject matters.

Our research and experimentation in the field of Scientific Studying yielded a number of efficiency-increasing methods; however, for the time being, the combination of division of time (into study activity segments and recreational activity segments) and subject matter alternation has yielded the highest performance. These two methods have their own optimal parameters and implements, and they should be used in addition to (and not in substitution of) all other applicable methods, parameters, and implements found to be effective through the Scientific Studying discovery process. Note that as a related additional method, in an experiment we conducted, a limited number of students were asked to work out during the time allotted to the recreational activity. This provided for a considerable increase in learning power. In fact, studies reveal that brain activity (as in a decision-making task) increases more rapidly following a time of intense physical activity such as running on a treadmill [3]. Researchers estimate that simple aerobic exercise improves episodic memory and executive-control functions by about 20% [6]. We expect that extensive use of this method could yield a considerable increase in learning power.

5. Conclusion

We contend that the best strategy toward increasing the learning power of students and, consequently, the level of education in our society, is to create a new subject matter in the curricula of schools and universities that would teach students to scientifically learn how to learn. Consequently, teachers and professors would become familiar with the Scientific Studying approach so as to coach the students in their experiments. The instructors would not only provide guidance to the students on how to make scientific experiments, but they would also propose an initial set of different methods, parameters, and implements, based on the overall most successful ones observed in the other experiments. In fact, the experiments we performed reveal that there are certain similarities between the optimal methods, parameters, and implements chosen by the students. It may be the case that there exists a universally optimal learning methodology. Evidently, the more experiments that are conducted, the more results will be communicated and analyzed, and the more it will be possible to determine a generally optimal learning methodology.

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