Quantitative Aspects of Knowledge
Knowledge Potential and Utility

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ABSTRACT
In this paper, we enhance and extend the quantitative theory of knowledge. It emphasizes the truism that academic knowledge is acquired over a time by process of learning from faculty and staff at the colleges and universities. A formal model of student environment from high schools to various levels of universities granting doctoral degrees training is assumed in this research. In this paper, we also include the effects of learning in post secondary schools and in post-doctoral institutions. The net effect is that most human beings continue to learn but to varying degrees depending on the characteristic of the student/employee, the faculty attitude to teaching/job environment and the duration of such interactive process. The proposed model allows for desirable growth of individuals who reward the society in a beneficial way. This is the primary reason for the development of the model. However, the same model is also applicable for those who live to hurt and destroy social values. The Mafia schools and warring nations train their terrorists and offer them all the lethal tools of hurt and destruction. The systematic decay of human civilizations appears as scientific to the negative thinkers as the science would appear attractive to the civilized societies. The portrait of different forms of life is thus tracked as a mathematical approximation based on statistics and norms drawn from the society itself. The model is predictive and becomes a good leading indicator of where living and learning can take any individual over a given period. Different scenarios of student personality who learn to earn, who learn to learn, who love to learn are presented in conjunction with the faculty personality who teach to earn, who teach to educate, who love to teach are examined to gauge the knowledge potential gained by the learners from postsecondary training centers to postdoctoral centers advanced research and social contributions.

Keywords
Knowledge Acquisition, Knowledge Potential or KnP, Knowledge Deployment, Utility of Knowledge, Annual Income.

1. INTRODUCTION
Quantitative measures of knowledge exist in the literature [1], even though they are not widely used. A greatly enhanced model in this paper is based on two axioms that (a) that learning and living are two continuous processes
and (b) that the society rewards the human beings by the expected contribution to the job environment. The caliber of learning is established by the knowledge potential gained by the individual\(^1\) at any given stage in life. At the lowest level of mandatory secondary school, the Knowledge Potential\(^2\) (or KnP) is relatively low at level of \(0^\circ K\) at the graduation from high school or at subzero level for lower level. Through the continued schooling, the KnP can reach levels of 100± at the Bachelors’ Degree level, levels of 220± \(^\circ K\) at the Masters’ Degree level and attain levels in a wide range \(270^\circ K\) to \(1004^\circ K\) (or even higher) at the Doctoral Degree levels. Differences in universities, faculty and facilities influence the institution tier levels. Though not important at the lower levels of learning, these differences become influential in the KnP gained by the students at the Master’s and Doctoral Degree levels. Individual differences in the student capabilities are also reflected by their achievements and the Grade Point Averages (GPA’s). In addition, the students who wish to finish their degree as their ulterior motives of learn only to earn, whereas students who actively pursue the degree to learn acquire higher KnP’s throughout at an exponential rate, through their post-graduate programs and perhaps the rest of their lives.

There is a surprising extent of correlation between the annual incomes with the KnP’s gained at almost all levels of education from secondary school to postdoctoral training. The study confirms two universal observations. First, those learning only to earn and gratify their own lower level needs\(^2\) as human beings, reaches a premature saturation level at lowest income level of about 20-22 thousand dollars (2012 National Labor Statistics). Second, those learning to learn the skills to gratify the outstanding social/technological needs saturate at 4 to 5 times the annual income (2012 National Labor Statistics) at graduation. Further, those who continue to live and learn together reach a much higher level and the accelerated growth continue until the biological process of age hinder the learning, memory and retention functions.

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\(^1\) The learning scenario is universal in all situations of a student in a school, a disciple in a shrine, an apprentice in a job, a child from a parent, an intelligent chip in a network, etc. The flow of knowledge (unidirectional or bidirectional) like the flow of power, are the prime features in consideration.

\(^2\) The symbol \(^\circ K\) should be treated as degrees of knowledge and not as degrees Kelvin as a measure of the temperature. The interpretation should depend in the context of knowledge and not as the temperature. Thermodynamics (with \(^\circ A\) and \(^\circ K\) to designate temperature) is a branch of Physics whereas Knowledge Science (with \((^\circ K)\)) is a branch of Learning and Education and Retention of knowledge after various levels of Schooling.
2. REPRESENTATION OF GENERIC FORMAT OF INTERACTIONS

Knowledge is generated when any noun (object) performs a verb function; how the verb is performed, adds more dimension(s) to new or the older knowledge already collected and stored by noun object(s). The value of such knowledge can rank as low as triviality, a reiteration of what is already known, or as high as new oracle(s) of perpetual wisdom. The structure of knowledge can be founded on this truism.

2.1 Truisms about the Structure of Knowledge

Knowledge results due to effects of interactions between noun objects (no’s) and verb functions (vf’s) and vice versa. For example, when one human talks (*) to another and the other responds, knowledge is generated. How the interaction takes place adds another dimension in the interaction process and its effects. For example, if talks are replaced by “yells”, then the effects that follow can be different.

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There are five components (a through e) in such an interactive process.

A noun object no1, initiates a verb function vf and the mode of interaction is established as *. This basic elementary process is represented as

\[ no_1 * vf. \]

Further, broken down this process is written down as:

\[ no_1 *_{12} vf_{12} no_2 ; \text{ or as } \]

\[ no_1 vf_{12}* \rightarrow no_2 \]

and its response from no2 is written as:

This entire element of any elementary transactional process can be written as:

(i) a forward process by no1 (full lines)

(ii) a backward process by no2 (dashed lines)
in a time sequence. Represented as a diagram the, \( a \) to \( j \) interactive process is depicted as:

![Diagram of an interactive process between two participants \( n_{o1} \) and \( n_{o2} \).]

This diagram does not have an easy flow chart that can be implemented on a computer system. However, the diagram can be partitioned into two symmetric halves, one for each participant and linked via a current interactive event in a process.

Any number of these processes will give rise to an interaction and knowledge is accumulated at each of the minor steps \( a \) through \( j \) in each process depicted as \( \rightarrow \) and by the directional arrows. Significant knowledge is added when these steps are arranged in an orderly and systematic fashion. Such accumulated knowledge can occur for a few microseconds in computerized and networked elements it can occur over decades and lifetimes in cultures and societies. In Figure 1, the methodology for the accumulation of knowledge has syntactic and semantic relations between the elements \( a \) to \( e \), and then through \( f \) to \( j \) and then again \( a \) to \( j \) in a contextual sense. The rules for the flow and accumulation of knowledge have their cultural and societal foundations.

2.2 Computational Approach to the Generic Interactive Process

The logical and functional processes in Figure 1 are not evident to be programmed on a typical computer system. Programming of social computers can become a selected expertise. Alternatively, definitive approaches become necessary to force the constraints in the social elements of any social system to be simulated on any typical computer system.

Two such parameters are reversibility of the social elements and the continuous scanning of all parameters of each social element to forcing the computer system to emulate the social system. Social systems act and react in real time; and the simulation software should be able to track the changes of all parameters that influence the social interaction. However, the representations in Figure 1 can be decomposed by realizing the roles of the interactive participants are reversible and symmetric, i.e., the processes of \( n_{o1} \) or \( n_{o2} \) can be imaged in subroutines but with the parameters being updated from those from \( n_{o2} \) to \( n_{o1} \) respectively, and then the vice versa. A programmable flow chart of the generic interaction process is shown in Figure 2.
The generality of the interactive professors depicted in Figures 1 and 2 is exemplified in the three following situations. First, a student and teacher interaction is modified by a history of prior events stored and updated in the computer memory. This depiction is programmable by two routines or tasks for the CPU that functions for \( n_1 \) and \( n_2 \) alternately to depict one or more series of interactions. Second, an atom of carbon can interact with a molecule (two atoms) of oxygen to form a molecule of \( \text{CO}_2 \). The bondage between the atoms is a programmable set of events that makes one molecule of \( \text{CO}_2 \). Third is a universal example for all species. One of the XX or XY chromosomes from the male sperm interacts with one of the female XX chromosomes to make the genetic imprint of the unborn baby. Randomness and statistical coupling occurs during most of the natural process, such as the birth process of a fetal, or the germination of a seed. Such interactive processes are innumerable and most prevalent in nature.

2.3 Interaction of Knowledge Elements in Human Minds

An element of knowledge in mind is like a chromosome in the womb. Under controlled environments, a new specimen (or even a new species) may evolve. Largely, the processes are probabilistic and circumstantial and the new product of knowledge-evolution can occur as a coincidence or as a matter of intense training in shrines and universities. It is our contention the pearls of wisdom and invention can be farmed by careful implanting of pearl fragments in the tissues of an oysters. A nursery for pearls can be reconstructed in the universities much like an artificial pearl-farm in tropical oceans.

3. KNOWLEDGE ACQUISITION IN INSTITUTIONS

Most institutions generally offer a systematic and a stylized format of learning for students. Typical schooling in the United States consists of Secondary and High schooling followed by formalized junior and/or senior college education and finally graduate education, for the Masters, Doctoral and Post-Doctoral training or internships.

During the last few decades, knowledge is gained in a series of classroom sessions with well-defined faculty and over finite durations of time (class hours per week during semesters and 2/3 semesters per years). Knowledge gain can thus be integrated based on the attitudes of the students, the setting of the institution, type and quality of faculty members, and the duration for the degree(s). On a statistical basis, the parameters that facilitate the educational status, or the potential of knowledge of each student, become quantifiable. In a sense, the compilation of knowledge in the human mind becomes an integrative process and it can the represented as a knowledge potential (KnP) in degrees of knowledge symbolized as a finite number of \( K \) in the knowledge domain.
3.1 Knowledge Potential Defined

Knowledge potential of a student is a number (measured in degree of knowledge or $\circ K$) gained by the student\(^3\) from numerous faculty members over the student ($\leftarrow$ and $\rightarrow$) faculty contact integrated over the duration of the study/contact. The parameters in the leaning process(es) are individual and/or statistical, the integration is mathematical, and the type(s) of interaction is definable by the social/cultural modes of behavior such as collegiate, friendly, congenial as in civilized and elite circles, or even hostile, detrimental or destructive as in brutal, invasive or wars. A (temporarily) stationary baseline of knowledge is desirable in most situations and can be arbitrarily chosen to suit the particular study. For graduate studies, we have suggested at school graduation the knowledge is at $0 \circ K$.

In a strict sense, the knowledge potential of any individual should be considered as zero at the formation of the seminal cell with inception of XX or XY chromosomes derived from the male and the female of the parent members in any given species. The knowledge is thus embedded in the genetic code with certain degrees of conformity to offer the physiology of the member species and a certain degree of latitude to give the freedom of the personality of the fetus. For genetic studies, the baseline with a KnP of $\circ K$ is perhaps founded in the knowledge embedded in genetic coded of parents or ancestors.

Knowledge potential has a utilitarian value. In an immediate sense, it indicates how that potential can be utilized for solving current problem(s) at hand. While the quality of the solution may be the highest in the direction of the specialization, the enhanced training that was necessary to attain the KnP will also be valuable for solving generic problems. For example, a Master's degree holder in Biochemistry with a KnP of 240 $\circ K$ may solve a problem in organic chemistry much better than a layman. In a longer term perspective, KnP multiplied by the expected contributions for 30 years in the career trail would have a utilitarian value of 7200 knowledge-years. Certain precautionary rules should be considered since the KnP value can swing up (or down) by the job effects, social setting, diligence of the individual, etc. In reality, the acquired skill over a lifetime can be significant.

\(^3\) The scenario is universal in all situations of a student in a school, a disciple in a shrine, an apprentice in a job, a child from a parent, an intelligent chip in a network, etc. The flow of knowledge (unidirectional or bidirectional) like the flow of power, are the prime features in consideration.
Figure 2. The depiction of a step in the interaction that has built-in memory effects for both participants and the effect on the current event in a chain of interactions. Full lines indicate student to faculty learning interaction and dashed lines indicate faculty to student teaching interaction.
In a true sense, the net utilitarian value should be an integrative process every learning experience of the individual. Furthermore, the acceleration of the learning process and its retention are both generally, the highest in the early job experiences compared to those in the declining year of one’s career. Some of these deliberations are considered by technical managers in corporations.

3.2 Student Traits

Students offer various mindsets to learning depending on “who” is teaching “what”, “when” the teaching occurs, and then “how” the teaching occurs. These variables contribute to the mindset in a psychological framework defined by “kristivity” (σ₀) in mind, a parameter unique to the student. Next, the path of communication (ℓ) and the area of psychological contact (a) combine to offer “kristance” (=σ₀ . ℓ/a kohms) that facilitates the flow of knowledge as current, and grow of KnP by an incremental amount. Initially, the quantity of knowledge received depends on the of the student.

3.3 Faculty Factors

In the prior section, faculty factor (f₀) influences the “who”, “how” and “when” aspects of the knowledge delivered to the student. This factor, though not very critical in the early stages of learning become important the student develops a personality and a mindset of his/her own. Thus the “kenergy” i.e., knowledge energy, delivered over a time will become

\[ K\text{energy} = (\text{KnP}_f - \text{KnP}_s) \times \{\text{Kurrent (as a function of } f_0 \text{ and kristance)}\} \times \text{Duration of Study.} \]

The stored version (or memory effects) of this kenergy enhances the KnP of the student. It is important to note this energy could be counter-productive and act as a drain on the energy already stored in the student KnP previously acquired. This condition frequently appears as confusion or negation on the part of the student. In general, this is frequent situation, found during a period of culture shock or when negative propaganda that is delivered by TV and Internet.

3.4 University Facilities and Settings

The environmental and extraneous factors, such as classrooms, libraries, duration of the commute, housing, and student facilities provide tangential effects of learning. Such effects may sometimes have emotional influences on the net change in the Student KnP. The gain of student KnP due to these factors may add or subtract some marginal numbers to the final KnP gained. Such effects are included by incrementing or decrementing the KnP gained.
4. GRADUATE EDUCATION

4.1 Masters Degree Students

The details of gain in the knowledge potential and a basis for the quantification of knowledge potential or KnP are both presented in Reference [3]. Knowledge potential is (almost) derived as the measure of temperature when an object (student) is in a hot/cold setting (Shrine/Mafia institution). The KnP rises to gain kenergy to serve and benefit the society or sinks low to deplete the morality and spread violence⁴. In this paper conductive mode of knowledge-transfer is considered, even though inspirational and Transmission mode are known to exist.

Knowledge potential thus serves as an indication of how well and how quickly individuals can address, comprehend and gainfully solve problems in unique, distinctive and creative fashion(s) that are also economical and productive. The concepts have been applied to the educational platform as students as they go through high school through to doctoral degrees (if they do). In a generic sense, this is a universal principle that if an solution of any problem is to be reached, the knowledge potential in each and every prior solution has to be evaluated and excelled by students.

The gain in KnP for Master’s Degree students is presented in Figure 3 and 4. The GPA along the X-axis is a good indication as to how well the students have integrated their learning to become knowledgeable. There are five (A through E) trends shown and indicated for the cases where the students with good and bad learning-attitudes learn from excellent, average and poor faculty members. The good students learn about how to learn while learning the course material and become proactive to the additional course material taught thus boosting their KnPs. The average students do learn but to pass the examinations and complete the degree. In a similar mode, the average faculty can teach the course material, whereas the excellent faculty would learn (love) to teach what they teach and how they teach.

This later synergy of faculty student interaction generates a series of Verb-functions (VF s) from the faculty to teach the foundations of course material knowledge, and conversely (VF s) from the students to distill concepts from knowledge and infuse them into wisdom trail of productive lives.

4.2 Doctoral Degree Students

The expected of KnP for the PhD students is shown in Figure 5. Three trends (A, B, and C) and two curves (D and E) are depicted.

⁴ This analogy can be taken only to a certain extent since no mature society need Mafia to survive, whereas cooling is desirable for life in hot environments.
Figure 3. Expected knowledge potential (KnP) of different students at the completion of Master’s degree. Some segments of these trends are exclusive by definition. For example, a student with really bad attitude (Trend E) gets expelled from the Masters degree program during the first one or two semesters and does not reach the high end of trend E. Conversely, students with good attitude, rarely remain in the lower section of trends C and D, but may decline to trends A, B or E during the Masters program by neglect or by abandoning their early attitudes. Student effort is thus a fundamental element in acquiring a high KnP. The figure indicates as a warning to those slipping and as an incentive for those who have fallen behind. Please see Section B under the current heading.
Figure 5. Expected knowledge potential (KnP) of different students after 24 months in the Master’s program. The minimum KnP level is tolerated by lower strata of universities and low quality of faculty members in such universities. Since the KnP is low in trends B and in A, most universities strive to at least meet or better the National average of the KnP level of 180 °K at the Masters Degree level. The top stratum of Masters degree holders with KnP of 280+ (see trend D), in most cases outperform doctoral degree holders with poor student attitude, poor faculty and at low level universities. Please see trend A in Figure 5.
Figure 6. Expected knowledge potential (KnP) of different students at the completion of Doctoral degree. As it can be expected, Plodders do the worst (A) and “Multiplier” students at poor universities do gain enough KnP to graduate. The “accelerator” students (D and E) do the best but are extremely rare, even though some faculty members and professional show this rare gift of accelerating faster than teachers and mentors. Multiplier students do better than plodders but still are not able to take full advantage of the faculty talent. Exceptional non-multiplier students at excellent universities will do as well as multiplier (B and C) students at low level universities.

Note: Plodders are students who keep plugging away as they did in MS degree program. They do not change their attitude toward gaining knowledge (KnP) during the doctoral years. “Accelerator” students combine their own skill sets exponentially (i.e., exponential of the KnP gained adds to their prior KnP) with the (poor, average or excellent) KnP delivered by faculty teaching.

(A) Plodders and Non-“Multiplier” Students, and Poor Faculty; Poorest Achievers.
(B) “Multiplier” Students, & Poor Faculty, Column (B); Average Achievers.
(C) Non-“Multiplier” Students, & Excellent Faculty, Column (C); Average Achievers.
(D) “Accelerator” Students, & Poor Faculty, High Achievers.
(E) “Accelerator” Students, and Excellent Faculty. Highest Achievers.

Non-“Multipliers” are average Students (GPA=3.5), Average Faculty (GPA=3.8) at the doctoral years. Plodders are students who keep plugging away as they did in MS degree program. They do not change their attitude toward gaining knowledge (KnP) during the doctoral years. “Accelerator” students combine their own skill sets exponentially (i.e., exponential of the KnP gained adds to their prior KnP) with the (poor, average or excellent) KnP delivered by faculty teaching.

Note: The numbers are statistically averaged. In reality, students can traverse the area between A and E during the doctoral years.
Figures 6 a and b, The trend indicates that at the highest levels of education, the KnP and salaries are the highest for this sparsely populated segment population and vice versa. In addition, at the lowest KnP levels, the national minimum wage ($7.75 per hour – 2012 rate) law also influences the total compensation. The HS diploma holders and post secondary trained employees are comparable in both their KnP’s and salary levels. The KnPs are derived from the training and its duration whereas the salary level is surveyed.

The choice of the most creative mentor is of significant to the future contributions of their doctoral student. To this extent, the training of the advanced PhD students becomes an art rather than a job. The Art of Scientific Investigation [4] in teaching becomes the practice of the superior faculty members and mentors as much as the art of learning to learn becomes the responsibility of the rare and exceptional students as depicted...
by the two exponential curves C and D in Figure 5. Post-doctoral training and internships can also be quantified along the basis of trends and curves presented in this paper.

The best of the students learn how to learn from the knowledge they have already received and then go on to apply the newly gained knowledge to further their KnP. An accelerative trend is established. The KnP thus grows at an exponential rate\(^5\) that reaches as high as \(1154^oK\) for the Doctoral students (with excellent faculty and 5 FTE years in an excellent university). Comparatively, the more mundane students reach just enough, as low as \(369^oK\) (with poor faculty, 5 FTE years at an inferior university), to get their Ph.D. degrees as job seekers! Unfortunately, after 5 FTE years of their lives, student in the lowest strata of doctoral student end up with a KnP that is just about or even less than the KnP of top MS students with excellent faculty in top institutions when they both finish their degrees. Top Master’s Degree graduates are sometimes more coveted than low-level doctoral degree graduates are as much as the top Bachelor’s degree students are preferred over the lower strata of Master’s Degree students. The starting salaries, as it is reflected by the Salary Surveys in the United States. The tracking of the statistically averaged trajectories for KnP, (2012) starting salary for Doctoral, Masters, and Bachelor’s degrees holders is evident\(^6\) in Figures 6 a and b.

5. CONCLUSIONS

The KnP’s developed in this paper are indicative of the employee or students ability to solve significant problems in a creative and beneficial fashion. Whereas these curves reflect the generally accepted notion that more education leads to better pay, we have a predictive model that related higher education implies higher computable KnP and thus a higher income. This intermediate parameter (KnP) is a computed based on employee or student traits, industry or university setting, and the quality of management or teaching/research teaching faculty. We also indicate the parameters that influence the final KnP of the student at graduation and training received after as an extrapolation of the gain in the KnP during the employment or

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\(^5\) Out of the 20 student mentored, we found \(\approx 10\%\) (or even less, one with the traits of an accelerated learner and the other with an inclination to learn but unable to follow through) who were in the top category and 60-70 % in the mid range and then about 30-20 % who just wanted a Ph.D. degree to append their names.

\(^6\) After the Bachelor’s degree level in Figures 6a and b, a slightly bump in salary is seen. This is ascribed to the fact the more promising BS degree holders are lured into jobs while they could have easily enrolled in the Graduate programs of universities. Further, the desire to earn at BS degree shows a psychological peak than the desire to learn, thus the better students may compete and get higher salaries than average (B/B+) students who enroll in the Masters Degree programs.
college/institutional years. The model is entirely predictive but subject to the sampling error in the student, faculty and the university populations. By and large, the model is as accurate as the age and health prediction in any culture or society. Individual differences continue to exist; however, the circumstances can be consciously altered to maximize the possibility of being constructive and creative by extrapolating the knowledge gained thus far, into the environment of the culture and society.

REFERENCES


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