A model for realizing human potential

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A Model for Realizing Human Potential

Abstract

The realization of human potential requires each individual to consider their future possibilities relative to their current capabilities so that they may develop and execute a plan to gain knowledge, experience, and opportunities. Accordingly, a model is herein presented in which an individual's understanding of their own capabilities is informed by objective assessment after which that individual's perception of future possibilities is supported with a probabilistic career tree diagram. The proposed model provides a detailed registry of the individual's skills with indicia of scarcity relative to the needs of varying employment opportunities. In addition, the proposed model provides a roadmap for gaining knowledge and experience to advance and/or change careers.

The proposed model provides not only a personalized and dynamic program of education, assessment, and certifications but also access to potential employers for the gainful application of human resources through an auction system to garner and allocate resources. While an example is provided for an Associate's of Science in Engineering degree using a variety of resources including Massively Open On-line Courses (MOOCs), the model is extensible to a diversity of professions and educational resources such as traditional college courses, industry seminars, and other hybrid programs that provide knowledge and abilities sought by employers. Each individual's potential can thus be realized by helping each individual to rationally choose their own career plan as a function of requisite costs, benefits, and interests.

The proposed model is feasible from a technological perspective, and could significantly increase the rate of return on education across a lifelong career. While the proposed model could significantly lessen income disparity, it would not eliminate income inequality or the need for continuing social entitlements. Given current educational trends and societal pressures, policies related to program accreditation and professional licensure should be adapted to emphasize licensing of individuals rather than accreditation of programs.

Introduction

Our system of higher education is obsolete. Our students and practitioners are not well served by traditional academic programs graduating degreed engineers with classical curricula characteristic of earlier epochs. There are issues with both cost and breadth. Kazmer and Bardaro[1] recently found that the rate of return using engineering education has declined to 6.5% from the 19.0% found forty years ago by Psacharopoulos[2]. Regarding breadth, Bigliardi et al[3] advise managers of technical staff to develop and encourage lateral career moves of engineers, particularly for newcomers, by offering a variety of experiences that is likely to speed and better define their self-concept.

Of grave concern is widening income inequality, an inequality that potentially threatens our very social stability. Economist Tyler Cowen[4], among other popular works[5, 6], suggest that "average is over" and increased income inequality is inevitable. In Cowen's opinion, the U.S. government will continue to provide increased entitlements (subsidized housing, food assistance, health care, and ultimately a guaranteed minimum annual income) to "recalibrate" societal norms and thereby avoid riot and revolt. Such a "recalibration" through public policy may be feasible, but is probably not optimal with respect to maximizing total human potential and quality of life. Cowen posits that the fundamental cause of increased income inequality is the lack of human motivation to increase his/her human capital, even with the theoretical availability of free and high quality education.

We believe that our educational system, public policies, and societal norms must evolve to facilitate the development of all human potential. The model proposed here supports the development and fulfillment of rational expectations through several elements each of which leverages open information flows and free market principles:

- Assessment of current capabilities through cloud-based administration of certifications, course transcripts, and endorsements to provide a detailed registry and analysis of human expertise, more robust and quantitative than a resume or LinkedIn profile;
- Synthesis of probabilistic career possibilities, presented as a tree diagram, each with an actionable roadmap of required courses, certifications, and experiences along with cost and time estimates to completion;
- Analysis of current and future salary profiles derived from big data such as federal salary reports and self-reported data to provide cost:benefit analysis of potential investments;
- Facilitation of negotiations between individuals and human resource consumers (corporations, government, and non-governmental organizations) and third party suppliers (educational institutions, banks, foundations) to facilitate the realization of human potential.

The Model

Each of the model elements is next presented followed by discussion relative to other research. An example for an Associate's degree in engineering was purposefully selected for several reasons. First, the curricula for this degree is readily understood by the engineering education community. Second, the example may be informative to the general public contemplating the pursuit of such a degree. Third, there is a diversity of course and other offerings that might be used to satisfy degree requirements. Fourth, there is a diversity of educational and career pathways that such a degree may create. While engineering is the focus of this paper, the model is extensible to other degrees and, more generally, to different careers requiring a diversity of human capital.

<u>Part 1 – Credentialing & Certification:</u> A resume or curriculum vita provides a snapshot or view of one's professional life. Typical components that may be described include (in order of decreasing formality) degrees, licenses, job titles, certifications, self-assessed and peer-assessed skills, expertise, contributions, interests, and other endorsements. LinkedIn is one widely used system for managing and publishing these items. However, the LinkedIn system is deficient with respect to expertise decomposition/scaffolding, objective assessment, and verification.

For example, consider the sample resume for some J. Doe provided at left in Figure 1. The resume or LinkedIn profile provides an overview of accomplishments. The proposed model uses a variety of databases to deconstruct the high-level certifications, skills, and keywords into a detailed registry of lower level skills. For example, published curricula can be used to map a Bachelor's of Science in Engineering (BSE) degree to individual course plans to even more detailed course learning objectives. Similarly, industry certifications (e.g. Comsol Heat Transfer) can be similarly defined including pre-requisites and learning outcomes. Some keywords, such as the job title Design Engineer, imply a set of skills that may not be explicitly understood by a prospective employer. As such, a keyword database can be defined that maps keywords to underlying requisite skills.

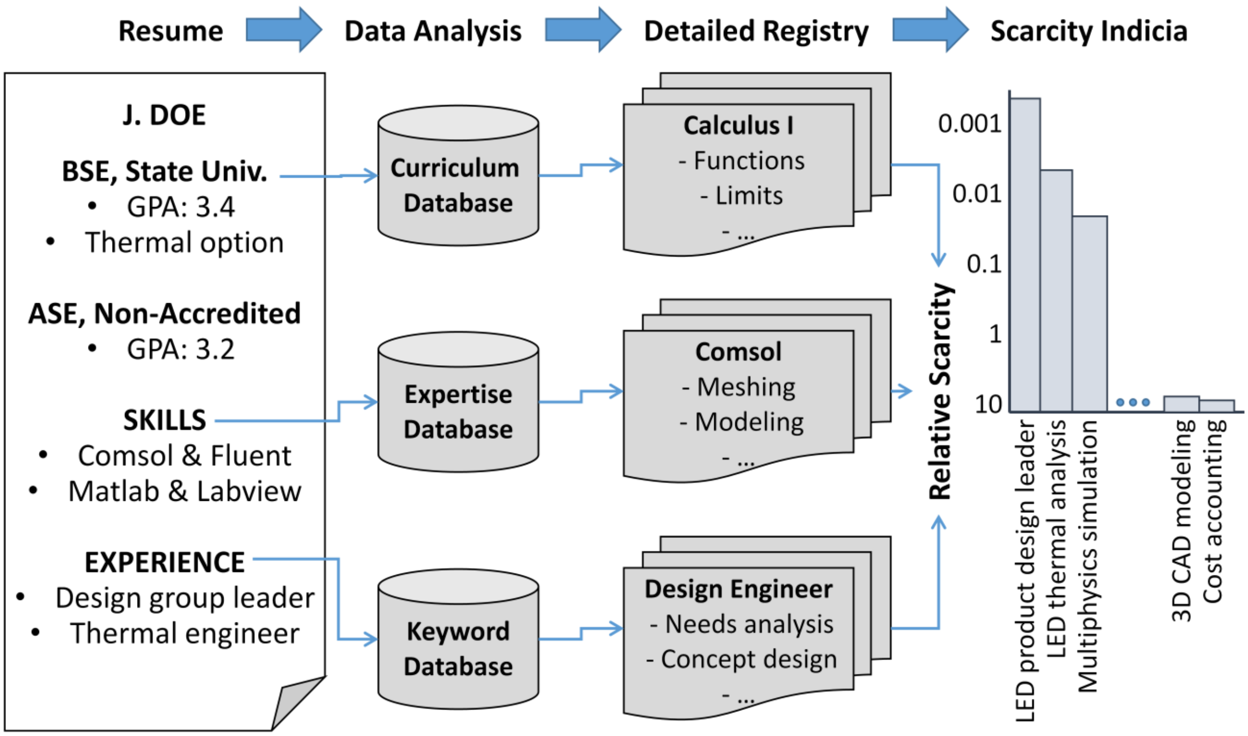


Figure 1: Expertise Registry & Analysis

The objective of the data analysis is to provide not only a registry of the various skills, but also statistical indicia of relative scarcity. Accordingly, the registry is intended to catalog measurements such as at least longevity, scores, and peer endorsements. Norms, such as vector multiplies or assessment of joint probabilities, can be used to assess the relative scarcity of higher level skills being sought by employers; Petersen et al[7] developed a stochastic career progress model that could be modified to assess progress and scarcity of expertise. In the example of Figure 1, J. Doe's expertise as a lead product designer for LEDs is shared by less than 0.001% of the working population while his/her knowledge of cost accounting is shared by at least 10% of the working population.

In an ideal world, an individual's skills/expertise would be fully observable, meaning that their skills and expertise would be objectively and exhaustively accounted. To the extent that observability is lacking, the proposed system attempts to "fill in the blanks" through statistical analysis of complementary items in the registry. The individual should be able to view and judge the validity of their profile assessment. If variances are found, corrective mechanisms should be made available. While beyond the scope of this paper, some correctives vary from on-line assessments developed by recognized experts to review of portfolios by professional organizations.

Part 2 – Career and Education Roadmaps: Given an individual's detailed registry, career and education roadmaps can be constructed. As a second example, let us consider an earlier roadmap for J. Doe provided in Figure 2. Suppose that J. Doe was then employed as a forklift operator in a warehouse. As a graduate from a vocational technical high school, J. Doe may have contemplated different careers. Their awareness of possible career options could arise from a number of sources, including feedback from a personal interest inventory or results stemming from analysis of the individual's registry within the proposed model. Regardless, let us presume that J. Doe wishes to pursue an Associate's of Science Degree in Engineering (ASE).

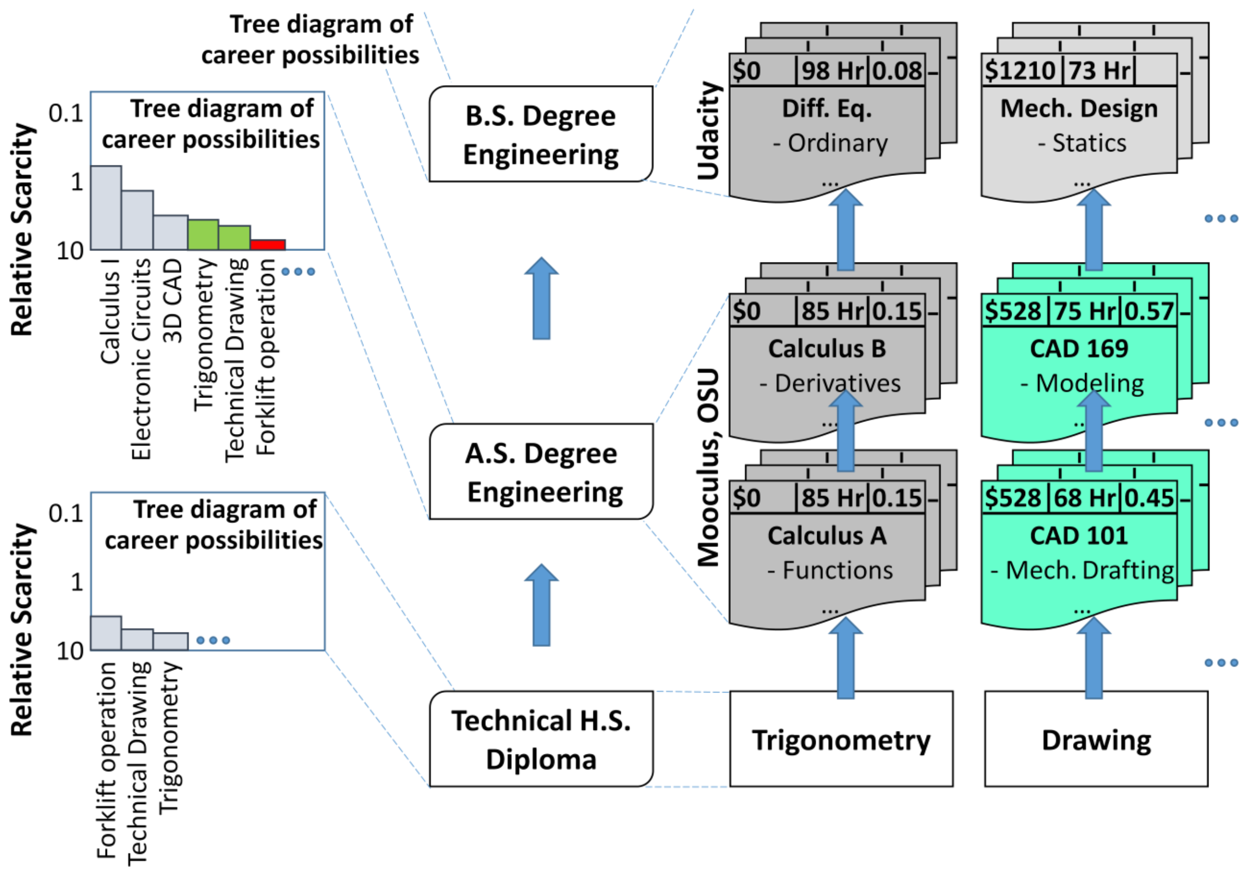


Figure 2: Career and Education Roadmap

Using the same curriculum database previously discussed, the proposed model can synthesize a variety of course curricula typical of ASE degrees including, for example, 30 credits of general education, 15 credits of mathematic and physical sciences, etc. The proposed model can provide a myriad of options for finding and enrolling in courses, with the individual provided full disclosure as to cost, workload, and success rates. For example, Figure 2 provides a portion of a an accredited ASE program including Calculus and CAD classes. The Calculus content could be fulfilled by passing a massively open on-line course (Mooculus, through Ohio State University) or traditional Calculus course at a community college or other public or private University. Similarly, the engineering courses could be taken at local colleges or on-line, when available.

The individual should recognize that a "fully accredited" degree will be obtained only by meeting all program requirements in which that student enrolls. Such programs typically have residency requirements and limits on the number and source of transfer courses. As such, the individual must determine their own best course of action, e.g. to enroll in a traditional program providing an accredited degree or pursue their own degree in a "university without walls" that may or may not provide them similar expertise but certainly provide them more flexibility and lower out of pocket expenses. We hypothesize that such unaccredited degrees in which curriculum requirements are fulfilled by a diversity of institutions are likely to become more prevalent in the future.

As the individual contemplates different program and course opportunities, their future career possibilities should be similarly considered. At left in Figure 2 are two graphs depicting the estimated relative scarcity of J. Doe's evolving expertise before and during their ASE studies. The proposed model augments the current expertise with Calculus, electronics, and 3D CAD with their completion in the ASE. At the same time, the proposed model considers the impact of the ASE with the individual's prior skills – in this case increasing the capability of trigonometry and technical drawing but reducing the forklift operation skill via a "forgetting factor" that includes technical obsolescence as well as knowledge degradation.

<u>Part 3 – Return on Investment:</u> There are many returns on an investment in education including knowledge for its own sake, increased contributions to society, and others. Still, return on investment (ROI) in purely economic terms is one metric that is widely reported and used. For example, Payscale.com uses a methodology similar to that reported by Kazmer and Badaro to estimate the ROI at the institution level. The same methodology can be applied at the program level using self-reported data to estimate salaries and ROI for various program majors by institution. Accordingly, an individual such as J. Doe may evaluate the ROI of alternative educational and career roadmaps based on their starting position as demonstrated in Figure 3.

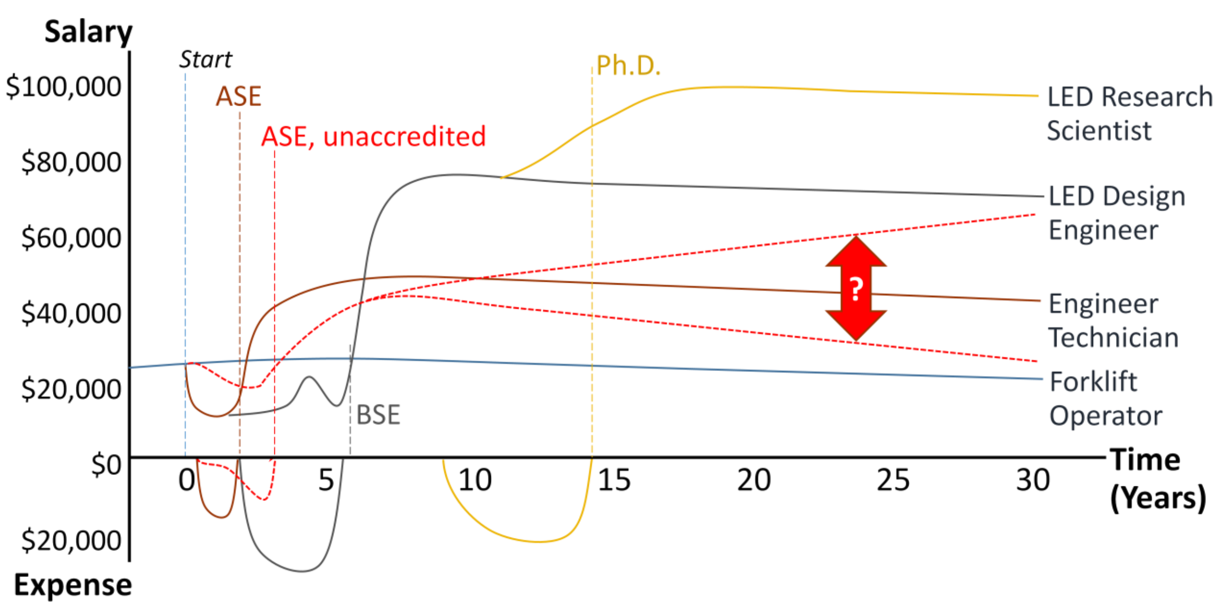


Figure 3: Salary Profiles for Various Career Paths

There are five education and career paths plotted in Figure 3. The first (lowest) path shown in blue is the salary profile for J. Doe if they were to remain a forklift operator; the salary averages around $27,000 per year peaking in 8 years and then declining gradually. An alternative, shown in dark red, illustrates the profile if they were to pursue and complete a traditional two-year ASE degree. The salary profile indicates a dip in salary as the individual is employed on a part-time rather than full-time basis. Additionally, there are expenses incurred related to tuition etc. As a result, however, their salary would likely rise to around $50,000 after a few years of practice before beginning a slow decline. It is interesting to contemplate the salary profile for the alternative unaccredited ASE degree that consists primarily of on-line courses. It is likely that such a degree would incur a lesser salary drop as well as lesser tuition expenses. After completion, the salary profile would also likely increase more slowly than an accredited ASE degree since there is no formal credentialing. Assuming that the unaccredited ASE degree provided similar expertise, however, the salary profile for individuals with the accredited and unaccredited degrees should converge in a meritocracy.

Kazmer and Badaro[1] found that engineering salary data, *s*, followed a Gompertz type sigmoidal behavior as a function of time:

$$s(t) = s_b(1 + r_s)^{t \cdot exp(t/\tau)} \tag{3}$$

where s_b is the base salary at the onset of engineering work, r_s is the annual rate of salary increase, t is the number of years of work experience, and τ is the half-life of the engineering salary function. This model suggests that all salaries will tend to decay unless rate of salary growth is high and the half-life of the career is long; only graduates from a few institutions were found to exhibit such salary behavior. Accordingly, Figure 3 also provides two career paths in which J. Doe contemplates the pursuit of a BSE and Ph.D. Again, the cost and benefits of each of these education and career paths can be assessed in an on-going, real-time fashion with continuing input as to the individual's expertise and market conditions.

Part 4 – Facilitation: Realizing human potential requires investment in human capital. A significant issue, especially among the poor and middle class, is the availability of resources necessary to not only meet the tuition and living expenses but also the loss of income associated with the temporary cessation of full-time employment. Reconsider the salary profiles of J. Doe in Figure 3. If J. Doe requires $20,000 to live, then the pursuit of an engineering degree will cause a negative free cash flow from the moment their working hours are reduced. The cash-flow trajectories for J. Doe in the pursuit of the accredited ASE, unaccredited ASE, and BSE degrees are shown in Figure 4. In all cases, there is a "valley of death" in which there is significant negative cash flow, similar to that experienced by a start-up during product development. The "valley of death" may be smallest for the unaccredited degree and largest for a traditional BSE degree, suggesting that there is a risk-reward decision that each individual must make.

As indicated in Figure 4, government and educational institutions support large student enrollments, garnering revenues across a diverse population. While such enrollments imply a significant risk tolerance, the tuition revenue is received early in an individual's debt cycle, insured by loan guarantees, and subsidized by government. The individual is often faced with hard economic and personal decisions at the mid-point of their academic program: will they persist to graduation, and how will they pay for their education? With such issues, it is understandable that financial hardship is a significant determinant of student withdrawals from college [8, 9]. There is currently little individual reprieve until the graduation and employment, even with scholarships and cooperative employment.

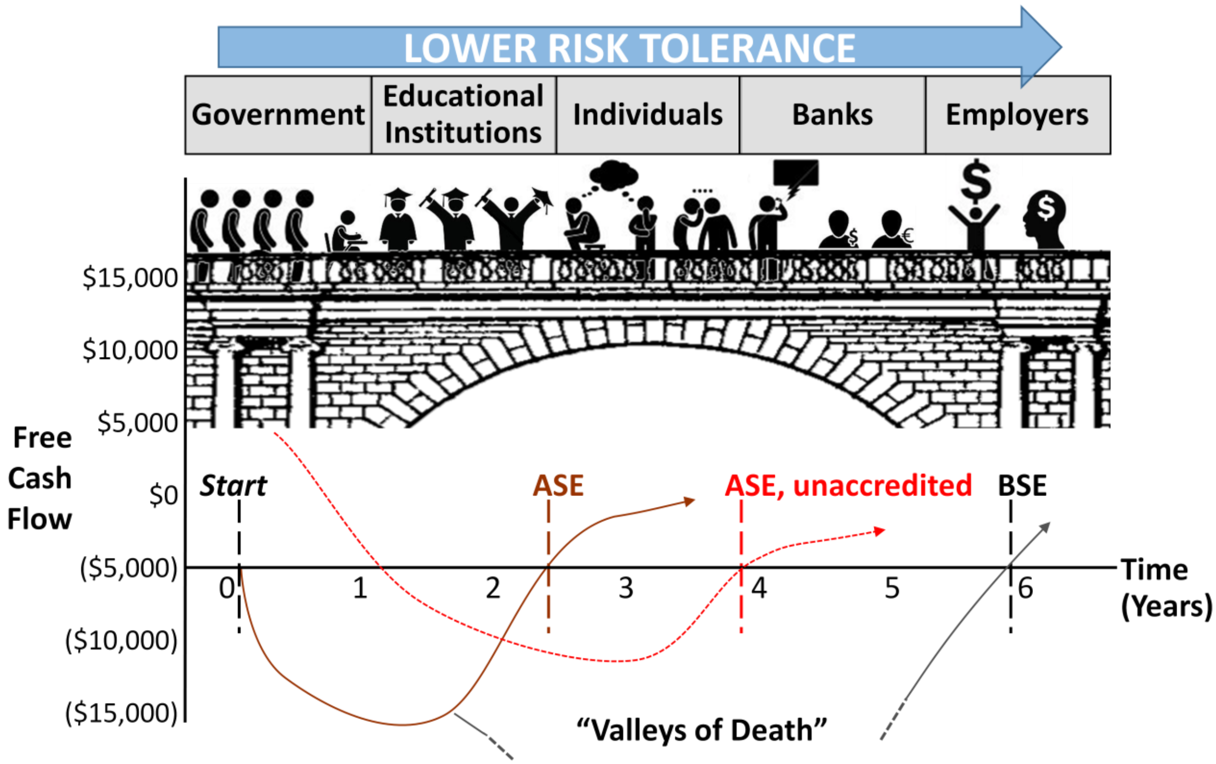


Figure 4: Bridging the "Valley of Death"

The proposed model would assist both individuals and employers by facilitating employment based on individual's registry of expertise as matched to employer's needs. While both forward and reverse auctions could be used, a forward (ordinary) auction is preferred in which employers would compete to hire individuals by offering increased incentives such as increased salary or tuition remission. The purpose of the auction mechanism is not only to facilitate the individual's employment and further development of expertise, but also collect data on salary as a function of the type and scarcity of expertise. The data input to the proposed model would thus be constantly updated in real-time to inform each individual's understanding of changing market dynamics and so plan their own strategy for maximizing their own human potential.

Discussion

Discussion of Motivation: It has been said that change is constant, but there is likely an increasing rate of change that is enabled by the application of increased technological and human capital. Accordingly, we foresee that current societal pressures related to income inequality and affordability of higher education will continue if not increase. The objective of the proposed model is to alleviate these pressures by realizing human potential to raise the salary floor much like "a rising tide raising all boats." The raising of salaries would occur by better guiding students' learning to support the technical and analytical skills sought in the workplace. Furthermore, there is also the opportunity to reduce costs by better utilizing the existing and developing curricula through a more open system of education.

Discussion of Assumptions: The proposed model assumes the validity of the theory of human capital operating in a free market. With respect to the theory of human capital, Spengler [10] argues that Adam Smith first implied the existence of monetary value in human capital: "The acquisition of talents, by the maintenance of the acquirer during his education, study, or apprenticeship, always costs a real expense, which is a capital fixed and realized, as it were, in his person." Pigou also suggested the importance of human capital with regard to trade-offs in its development [11]: "There is such a thing as investment in human capital as well as investment in material capital." The theory of human capital has since been more fully developed by various contributors.[12-14] By 1964, Becker's Human Capital examined marginal rates of return on education by comparing additional output relative to investment levels in human capital. [15] Becker recognized that while human capital is substitutable with respect to development and utilization, it is not transferable like other assets such as land, labor, or fixed capital. The theory of human capital thus suggests that it is rational for an individual to expect a real return from investment in their education.

Discussion of Design Intent: Some may consider the proposed model to be a soviet-style, centralized command and control system. However, the design intent is exactly the opposite by empowering everyone with open access to educational resources and employment opportunities. The system can be used by individuals to plan their own development and pursue career opportunities, by educational institutions to evaluate course development and program strategy, by employers to discover and further develop their own human resources, and other parties for integration and support of their own initiatives.

Similar to Facebook, LinkedIn, Monster, and other user-driven sights, the design intent is not to centrally populate the big databases needed to drive the system. Instead, the development strategy hinges on the implementation of relatively simple stochastic analytical models along with some initial data to spawn usage. Continued usage due to self-interest is expected to drive increasing data completeness and model fidelity. We recognize that monetization of such a model is possible, but is certainly not the focus of the current discussion.

Discussion of Impact on Income Inequality: Returning to the subject of income inequality, we do not presuppose the possibility of eliminating income inequality. [7] quantitatively demonstrated the age-old Matthew "rich get richer" effect, wherein the longevity and past success of an individual lead to a cumulative advantage in further developing his or her career. They developed a stochastic career progress model not dissimilar to that envisioned here, and validated their model predictions for several competitive professions. In testing their model on the careers of 400,000 scientists and engineers using data from six high-impact journals, they found that careers can be stunted by the relative disadvantage associated with inexperience. These and Cowen's findings suggest that variances in initial conditions and human motivation will propagate income inequality even with the proposed model. Still, it is our hope that the proposed model will provide a means for enabling the "other 90%" to pursue and realize a preponderance of their human potential.

Discussion of Impact on Education Affordability: Self-investments in education are staggered over time. Psacharopoulos [2] conducted a global study while working for the World Bank in which he found that the lower income nations received an average rate of return of 11.2% with a median of 6.4 years of schooling while higher income nations received an average rate of return of 6.6% with a median of 10.9 years of schooling. The reasons for diminishing marginal returns with increased education are that 1) the cost of education increases with the level of education, while 2) the payoff period shortens with one's remaining lifespan. Interestingly, this same study found that engineering provided the highest rate of return of all professional undergraduate degrees, equal to 19.0% in 1972.

[1] recently analyzed the rate of return using engineering career salaries from the payscale.com database relative to the average net student price of education reported by the Integrated Postsecondary Education Data System (IPEDS) maintained by the National Center for Education Statistics of the United States Department of Education. They found that the internal rate of return declined to only 6.5% across a forty year career. The results, consistent with escalating social pressure, indicate the need for new models of engineering education. The proposed model provides three mechanisms to facilitate the lower cost acquisition of knowledge and expertise. First, the proposed model can provide access to lower cost options for "sufficient" (if not "equivalent") courses in a curriculum. Second, the network analysis and presentation of these courses relative to employment opportunities can provide clarity in planning such that fewer courses are wasted. Third, the facilitation of employment opportunities alongside continuing education can lessen or altogether eliminate the negative cash flow and associated "valley of death". As a result, the proposed model should increase the return on investment in education through a career with lifelong learning.

<u>Discussion of Policies Related to Accreditation and Licensing:</u> ABET is a nonprofit, non-governmental organization currently consisting of 33 member societies that evaluates an individual program of study, rather than evaluating an institution as a whole. It is certainly possible that each of those 33 member societies could endorse educational and career plans to certify an individual's expertise using the proposed model. Such support would certainly assist the proposed model's dissemination and act as a change agent applying pressure to conventional degree programs. However, we recognize that such support is unlikely for a variety of reasons.

Still, the proposed model may prosper without direct support from ABET or other professional societies. The reason is that, in many states, licensure as a professional engineer can be obtained, without an accredited degree, by obtaining credible years of experience as an engineering intern and passing a series of licensure exams. Furthermore, employer demand for human resources with "better skills" (this term is recognized as subjective; interpreted here as meaning "meeting *their* specific requirements") may drive free market acceptance of credible if non-accredited programs. In conjunction, policies related to accreditation and licensure may be adapted to emphasize licensing at the individual level rather than accreditation at the program level.

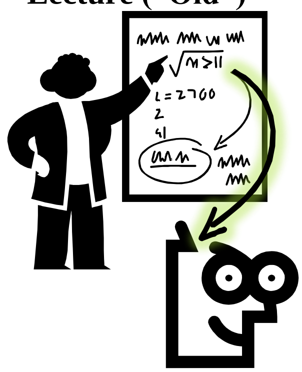
<u>Discussion of Policies Related to Entitlements:</u> The proposed model seeks to facilitate the realization of human potential; increasing human potential requires investment in human capital. We recognize that each individual's motivation is constrained by their understanding of what is possible. Cowen's suggestion of increased entitlements including health care and a guaranteed minimum annual income may, in fact, be compatible with the proposed model. The reason is that such a safety net would allow each individual to take risk without risking abject poverty. If entitlements and tax policy are appropriately set, individuals would be rationally motivated to

continue their lifelong learning when the benefits of such investment outweighs the costs. As such, entitlements and taxes should not be so high as to provide disincentives.

Conclusions

If we want to address the root causes of the problems articulated in this paper, we need to radically restructure the academy and challenge old ways of thinking. Table 1 provides a comparison of "old" and "new" paradigms of education that correspond to lecture and active teaching styles as described by Johnson, Johnson, and Smith.[16] The proposed paradigm is based on a social context in which students act as problem solvers in which knowledge is globally shared. Faculty provide coaching, including both motivation and assessment, while facilitating relationships in ad hoc, peer to peer networks. The assumption is that students can self-actualize, using the proposed education system to realize their human potential.

Table 1: Evolving education paradigms

	Lecture ("Old") [16]	**Active ("New")** [16]	**Social (Proposed)**
Paradigm & Illustration			
Knowledge	Transferred	Jointly Constructed	Globally Shared
Students	Passive Vessel	Active Constructor	Problem Solvers
Faculty Role	Classify and Sort	Develop Talents	Coach, facilitator
Relationships	Impersonal	Personal Transaction	Ad hoc, peer to peer
Context	Competitive	Cooperative	Social
Assumption	Any Expert Can Teach	Teaching is Complex	Self-Actualization

The proposed education system is intended to link diverse curricula to developing student expertise, and this developing student expertise to employment opportunities. The system is based on open-access information model using existing social network technologies with which students are so familiar. The proposed system could be implemented, possible, as a joint venture between existing organizations (e.g. LinkedIn plus PayScale plus Monster plus Coursera). However, such a purely commercial approach would likely fail due to conflicts of interest and lack of clarity of vision. Accordingly, we suggest that the proposed system might be prototyped on a small scale with respect to a specific "niche". Further feasibility and market analysis is needed to develop an appropriate development strategy.

Although we are not advocating a change in the core functions of creating and sharing knowledge, the proposed paradigm calls for dramatic changes in the way we think about academic roles and rewards. If successfully implemented, the system would facilitate education and career planning in conjunction with monetary analysis of the resulting expertise afforded by gainful employment. The resulting cost:benefit analyses, if performed on a widespread basis by each individual according to their own interests and monetary preferences, would assist all people to realize their own human potential.

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